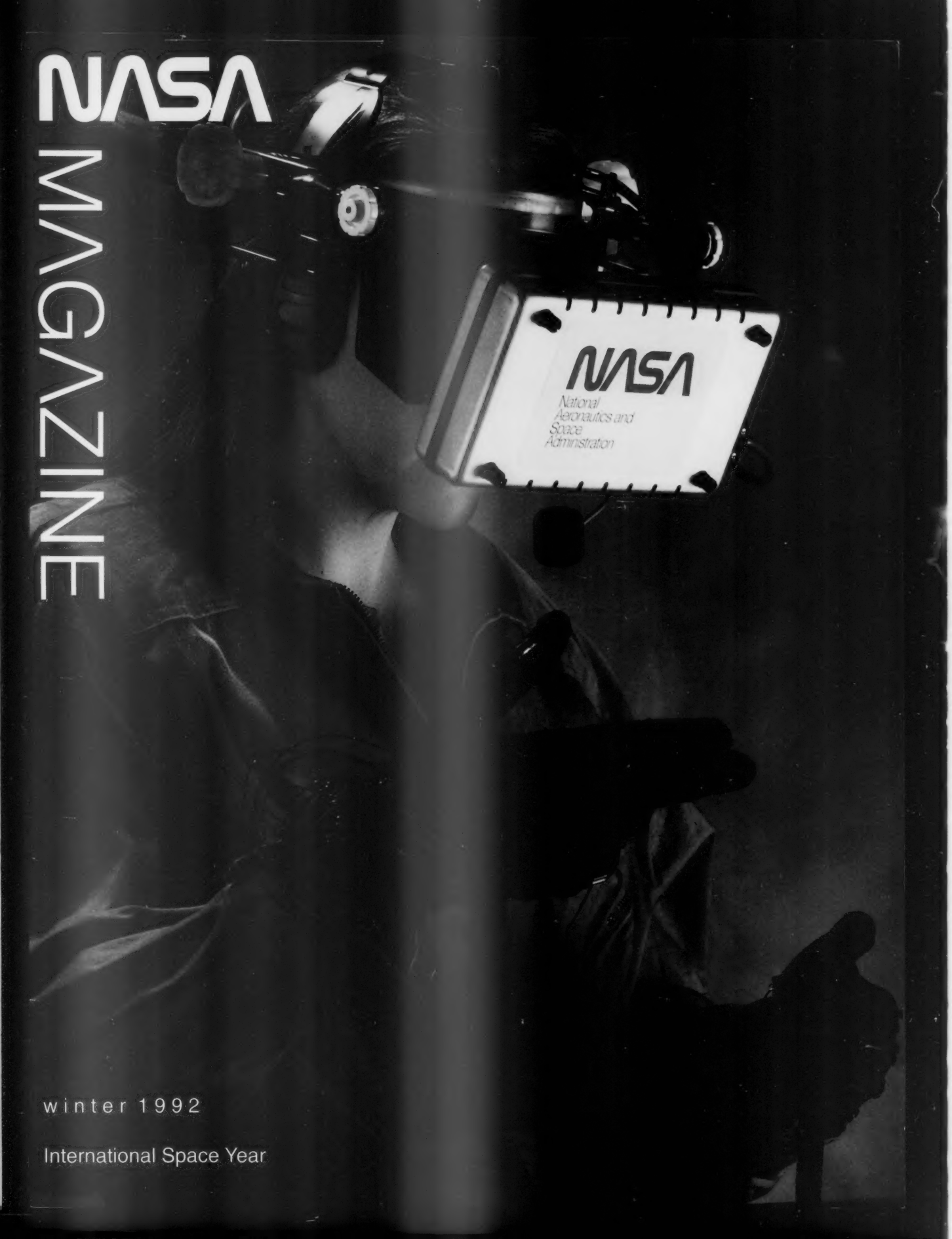
NASA MAGAZINE



winter 1992

International Space Year

from the administrator

"History has shown us that great nations dare to explore, and the benefits are many. ...The space experience has, in fact, transformed the way we live. From instant global communications to medical technologies enhancing everyday life, we are reaping the benefits of our missions."

1992 promises to be one of NASA's most challenging and exciting years to date.

How fitting, that as we celebrate International Space Year and the 500th anniversary of Columbus' discovery of America, we stand on the threshold of enormous new accomplishments in space and discoveries beyond our imaginations.

Our plate is full with a wide variety of programs—from Endeavour's maiden voyage to the Search for Extraterrestrial Intelligence (SETI) to more than a dozen important scientific missions. We look forward to the completion of Space Station Freedom's design phase and the development of its hardware.

We look to advancing our knowledge about the environment, with Atlas 1 focusing on the Sun's influence, Geotail studying the solar wind in Earth's wake, and TOPEX/POSEIDON looking at the influence of the sea.

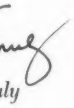
The list goes on and on.

History has shown us that great nations dare to explore, and the benefits are many.

The space experience has, in fact, transformed the way we live. From instant global communications to medical technologies enhancing everyday life, we are reaping the benefits of our missions. I invite you to read our cover story and think about how today's space program will help shape tomorrow.

I would also encourage you to read our very special "As I See It" feature, written by my good friend and former deputy, J.R. Thompson. I share J.R.'s view that, despite our critics, these are days of tremendous opportunity for NASA. We are a team second to none. Recent management changes have made us even better.

I look forward to working with all of you to make 1992 our best year yet!



Richard H. Truly

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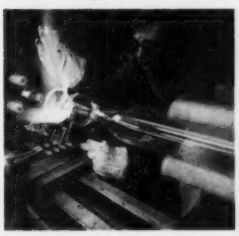

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COVER: A NASA researcher conducts a test of Ames Research Center's "virtual reality" headset. She sees a computer-generated three-dimensional scene or a real environment remotely relayed by video cameras. The headset's stereo imagery suggests she is actually part of the scene. Such technology could provide telepresence/ telerobotics capabilities for exploration on other worlds, as well as on our own. This issue's SPECIAL REPORT looks at today's technologies and how they might be used in the future. It starts with Spinoff 2022 on page 6. The photo is by Wade Sisler.

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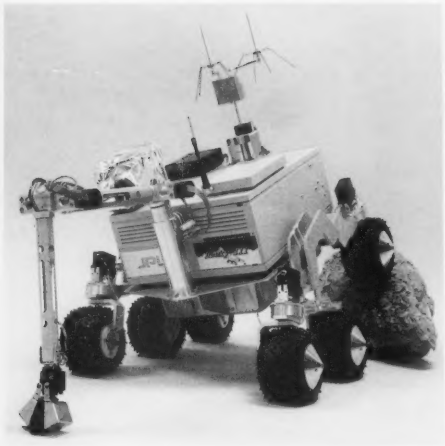
Mini-Rover Passes Driver's Test

Rocky III, a new class of roving robotic exploration vehicle, was tested last summer by Jet Propulsion Laboratory scientists in a region of California's Death Valley similar to the sites on Mars where the Viking I and II landers set down in 1976. The 56-pound mini-rover, which passed the tests with flying colors, uses newly available miniaturization technology and distributed communications that may allow robots to explore the moon or Mars in future sample return missions.



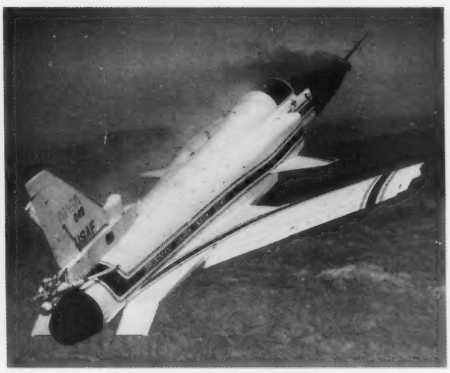
Rocky III or its derivatives could explore Mars.

Antarctic Ozone "Hole" May Have Twin

More than 100 scientists from NASA and other institutions are participating in a six-month study to determine the probability that a "hole" similar to the annual thinning of stratospheric ozone over Antarctica will develop in the Northern Hemisphere as well. The project, called Airborne Arctic Stratospheric Expedition II (AASE II), involves two NASA aircraft—an ER-2 high altitude research plane and a DC-8 flying laboratory, which will fly as many as 50 missions. The first results from AASE II will be available in the spring, followed by a final report later this year.

One Last Time for the X-29

The X-29 forward swept wing research aircraft flew its 374th and last flight in late September. The flight, conducted at the Ames-Dryden Flight Research Facility, concluded what NASA officials called one of the most successful X-plane programs in history. The X-29 proved that the forward swept wings with movable canards could perform and maneuver in high angles of attack as well as more conventional designs. The forward swept configuration reduces atmospheric drag by as much as 20 percent.



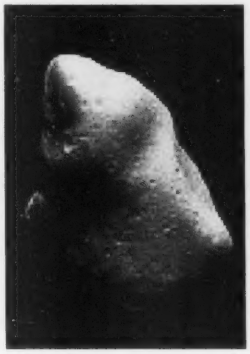
High over the Mojave Desert, the X-29 Blows smoke to show airflow.

In the Pink

NASA has successfully tested a new pressure-sensitive paint that can measure surface pressure on airplanes during flight. The measurements provide information on the strength of an aircraft's wings and tail used to certify or improve the plane's design. The new method, which uses light pink paint that becomes luminescent under ultraviolet light, is being hailed by aerospace experts as revolutionary because it may lead to the ability to map entire surfaces at once. Traditional methods produce data only from single, fixed points, and are expensive and time-consuming to install.

Portrait of a Wanderer

The Galileo spacecraft took the world's first close-up image of an asteroid just 34 minutes before it flew past Gaspra at a distance of 1,000 miles on October 29. The Galileo team expects to have the spacecraft transmit the remainder of the Gaspra observations to Earth sometime during 1992. The primary mission of the Galileo project is to explore the Jupiter system, beginning in 1995.



Asteroid Gaspra

President George Bush and NASA Administrator Richard Truly kicked off the school year with third and fourth graders from Washington, DC and La Porte, Texas in a September 17 broadcast originating on NASA Select. Astronauts Charles F. Bolden and Tamara E. Jernigan also participated in the program which was transmitted on PBS and carried by cable companies.

The New Face of Venus

Thanks to the Magellan spacecraft, we now have seen what Wes Huntress, director of the Solar System Exploration Division, calls the "new face of Venus." Scientists presented the first global maps of Venus in November, revealing a planet-wide fracture system across the equator and features that indicate a stretching of the planet's crust. The planet's highest volcano, Maat Mons, may even still be active. ●

1992 Marks International Space Year

The International Space Year (ISY) has begun. ISY is the first year-long worldwide celebration of our space age future. ISY will be highlighted by globally coordinated space activities during 1992 and planning for activities extending into the 21st century. A wide range of public activities, including films, expositions, and student programs is planned for ISY.

Global perspective is the major ISY theme, highlighting discovery, exploration, scientific inquiry and Mission to Planet Earth.

TRANSITION

Died

Dudley G. McConnell, Applications Director in the Earth Science and Applications Division at Headquarters, died October 28, 1991. McConnell, who was 55, had worked at NASA and its predecessor, NACA, for 34 years.

Honored

Neil H. Armstrong, the first man to walk on the Moon, has been inducted into Lancaster, California's Aerospace Walk of Honor. Also inducted were retired NASA research pilot Fitzhugh "Fitz" Fulton and the deceased Joseph Walker.

Armstrong, the Air Force's Pete Everest, and Fulton

Edward C. Stone, director of the Jet Propulsion Laboratory, received the 1991 National Medal of Science—for his work as Project Scientist on the Voyager mission.

Dolores "Dee" O'Hara, manager of the Human Research Office in the Life Sciences Division, Ames Research Center, has received the Women in Aerospace (WIA) 1991 Lifetime Achievement Award for accomplishments during her career.

Kathryn S. Schmoll, Assistant Associate Administrator (Institutions), Office of Space Science and Applications, has received the WIA 1991 Outstanding Achievement Award for her achievements.

Changing Jobs

Richard H. Petersen has been named Associate Administrator, Office of Aeronautics and Space Technology. He was most recently the Director of the Langley Research Center.

Paul F. Holloway is the new Langley Research Center Director. He had been the center's Deputy Director since 1985.

H. Lee Beach, Jr., named Deputy Director of the Langley Research Center. He had been Director for the Aero-Space Plane Directorate in the Office of Aeronautics and Space Technology.

Robert L. Crippen is the new Director of the Kennedy Space Center. He was most recently the Space Shuttle Chief.

John G. Mannix has been named Assistant Administrator for Commercial Programs. He was Director of Space Commerce Opportunities in the Office of the Administrator.

Arnold D. Aldrich is the new Associate Administrator for the Office of Space Systems Development. He leaves his position as Associate Administrator of the former Office of Aeronautics, Exploration and Technology. ●

"Do not pass go...Do not collect $14.1 billion." To appreciate the subtleties of the congressional appropriations process, it helps to be an aficionado of board games...forget what you learned in high school civics class.

The Game of Infinite Patience

by John Lawrence,
Office of Legislative Affairs,
NASA Hq.

To appreciate the subtleties of the Congressional appropriations process, it helps to be an aficionado of board games...forget what you learned in high school civics class. Despite the fact that the new fiscal year started October 1, the budget season is not yet over for NASA. Anything can happen, even now.

Before the ink was dry on the FY 1992 VA-HUD-Independent Agencies Appropriations Act (Public Law 102-139), passed in October, there was talk of further "potential" reductions to NASA and other domestic agencies in order to accommodate additional fiscal year 1992 spending requirements. An urgent 1992 supplemental appropriations bill followed shortly thereafter that could, in effect, redistribute FY 92 appropriations in ways that may further reduce the NASA appropriation. If the bill were to be enacted with the same spending formula as appears in the House-passed version, it would force a major budget sequestration in fiscal year 1992 for all domestic discretionary programs, which of course includes NASA.

At the same time as the 1992 appropriations debate was going on this fall on Capitol Hill, the Agency was in the process of formulating a 1992 operating plan and trying to negotiate the final FY 1992 Authorization Bill. That's right—1992. Forget what you learned in high school civics class again. An authorization bill is no longer a prerequisite for an appropriations bill, and most agencies can go years without ever getting one. It is NASA's good fortune to be an exception to that rule, because it keeps more members involved with and interested in the civil space program and space policy. Still, the enactment of an authorization bill *after* the appropriations measure does bring up interesting legal and political questions.

The really hot topic inside the Beltway these days, however, concerns the budget process and whether or not the five-year Omnibus Budget Reconciliation Act of last year, which established caps for discretionary spending, will survive the next session of Congress. Congressman Leon Panetta, the California Democrat who chairs the Budget Committee, already has announced his intention to review the budget situation "in light of the changes in the world and the growing economic and social needs of the nation." Optimists (if any still exist) might find some cheer in Panetta's inquiry into "whether the 1990 budget agreement should be breached or revised in fiscal year 1992 or 1993 to permit a transfer of funds from defense spending to domestic spending, or foreign aid, or tax relief, or deficit reductions, or some combination thereof." However, it is not yet clear whether the Administration is willing to deal, and it is even less clear that an election year is the best time to try and cut a deal if one is to be made.

The only thing that appears to be a given in the current environment is that NASA will not be able to sustain the same rate of growth in the '90s as it did in the '80s. As Admiral Truly recently noted in an address to the NASA Alumni League in Houston, "The next several years will be a period of belt-tightening, tough managing and restraint. But at the same time, you will see enormous accomplishments in space..." He went on to say that, "It is clear that congressional demands on NASA for stellar management and performance were never greater. Our projects must be on time and within budget. We must demonstrate clear-cut links between proposals and objectives."

The 1992 budget process was tough, and many participants would say we did not reap benefits commensurate with the effort. But we did get an increase and a commitment to some outyear growth at a time when most other agencies were cut.

Next year on Capitol Hill will be just as challenging. But with the support and dedication of the NASA team, the agency will respond to that challenge, we will pass "Go," and we will collect the funds needed to sustain a robust and diversified space program. ●

The Freedom Youth Academy is like no school you've ever seen before. Most every weekday from 4:30 to 8:00, Mary Ann and Henry Gaskins turn their home into a classroom. For the past ten years their special tutoring has given an educational boost to youngsters in the D.C. area.

The Home Schoolhouse

by Sonja Alexander, Hq.

It's four-thirty in the afternoon. Most students in the area are enjoying the end of another school day, but in southeast Washington, D.C., at the home of Mary Ann and Henry Gaskins, the day has just begun.

The instructions on the door read: "Classes are in session, ring once and enter." Inside, down the stairs and to the left, a classroom is busy with students preparing for their college entrance exams. To the right, in another room lined with bookshelves, students are grouped at tables receiving one-on-one tutoring from older students and parents. Farther on down the hall, you can hear the peeps and squeaks of computer keyboards—youngsters of all ages using educational software to help them with their studies.

Mary Ann Gaskins, an Advisory Committee Specialist in the Office of Space Science and Applications at Headquarters, and her husband Henry, a supervisor for the Library of Congress, have operated the Freedom Youth Academy in their home for the past 10 years. The after-school tutoring program helps students from first to twelfth grade gain skills that open the doors of educational opportunity.

Take Maria Coates' grandson Tyrone, for example. His abilities in reading and math have improved at the school, says Maria, and she "recommends the Academy for its one-on-one tutoring, which in most cases, the children are unable to obtain at school."

The Gaskins' efforts and the service and love they provide have gained national attention. The couple have received the President's Volunteer Action Award, the most prestigious award given for volunteer service, and Kleenex gave them its "Bless You" award for their endless hours of volunteer work. But when asked what award they value most, their quick response is: "Our students." The real reward, says Mary Ann, comes from seeing students go on to pursue and achieve some of their life goals.

The Gaskins encourage their students to think, and they don't mind giving them a little push every now and then. The results can be immediate. After attending the Academy for about four weeks, tenth grader Marcus Sills says, "You're always learning, and you're encouraged to think. I've noticed that my comprehension skills are increasing as well as my capabilities to retain more."

Parents are encouraged to play a large part in the Freedom Youth Academy, as well. They help with the students, read, study, or just relax in a lounge next to the classrooms. Myrtle Washington, whose son Benjamin attends the school, likes the multicultural atmosphere and the warm environment, and she contributes by teaching at the academy.

With all that activity going on, the time passes quickly, and another day of classes at the Freedom Youth Academy comes to an end. Ready to wind down at the end of their own long day, Mary Ann and Henry Gaskins look around, satisfied with the results of their "moonlighting."

Eight o'clock. Time for their schoolhouse to become a home again. ●

JANUARY 10, 2022, KOUROU, FRENCH GUIANA—

At 6:16 a.m. GMT, a crew of eight people took off on the third human mission to Mars, intent on thoroughly investigating the astonishing discovery, in 2019, of signs of ancient life on the Red Planet.

Members of the second human expedition to Mars, landing on the planet a little less than three years ago, found fossilized multicellular life forms in core samples of surface materials taken near the equator. While the fossils look like nothing known to have ever existed on Earth, they are indeed life, according to the world's top biologists and exobiologists.

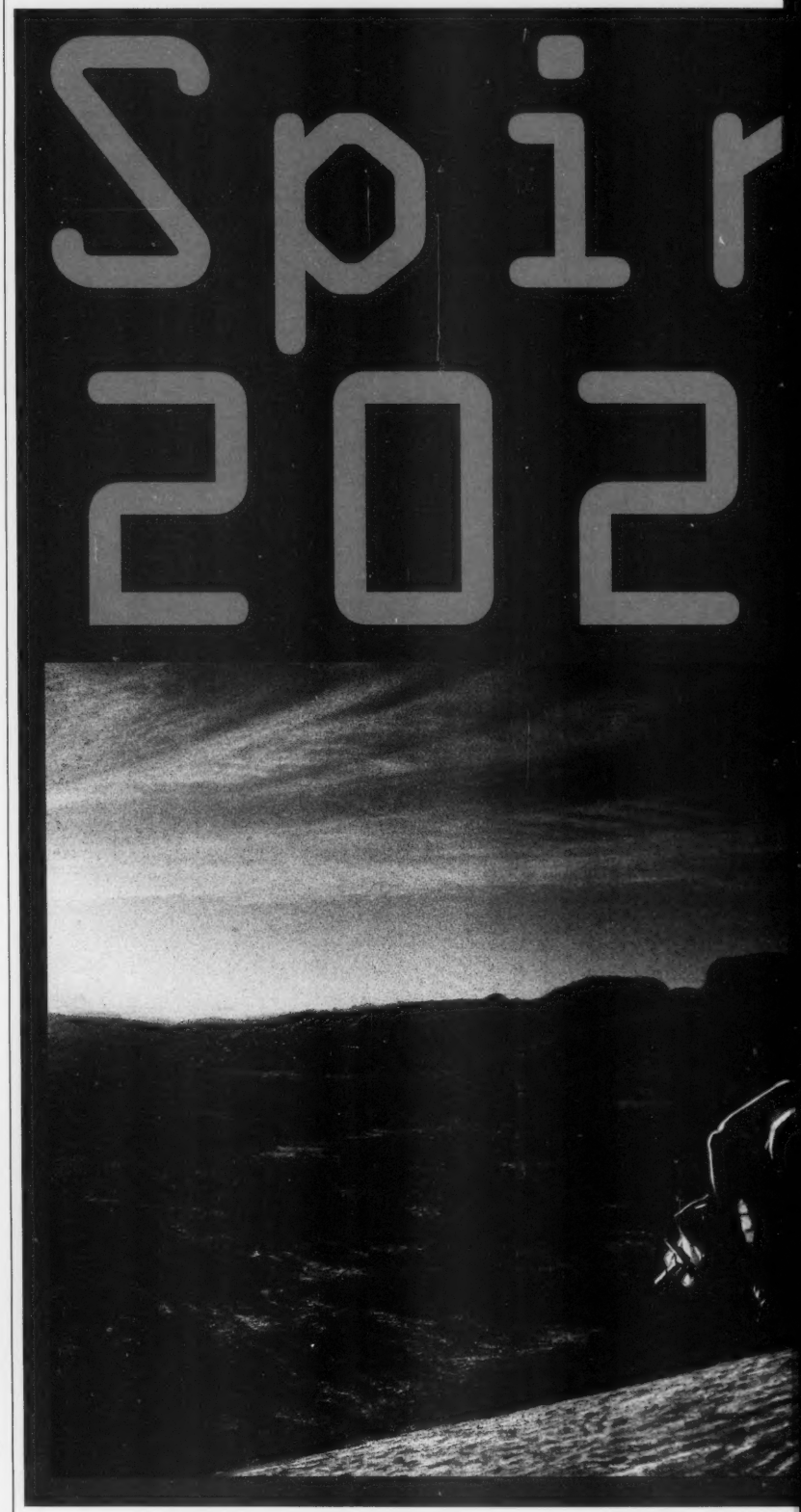
Scientists are touting this find as the most revolutionary discovery since Crick and Watson figured out the structure of DNA in the mid-20th century....

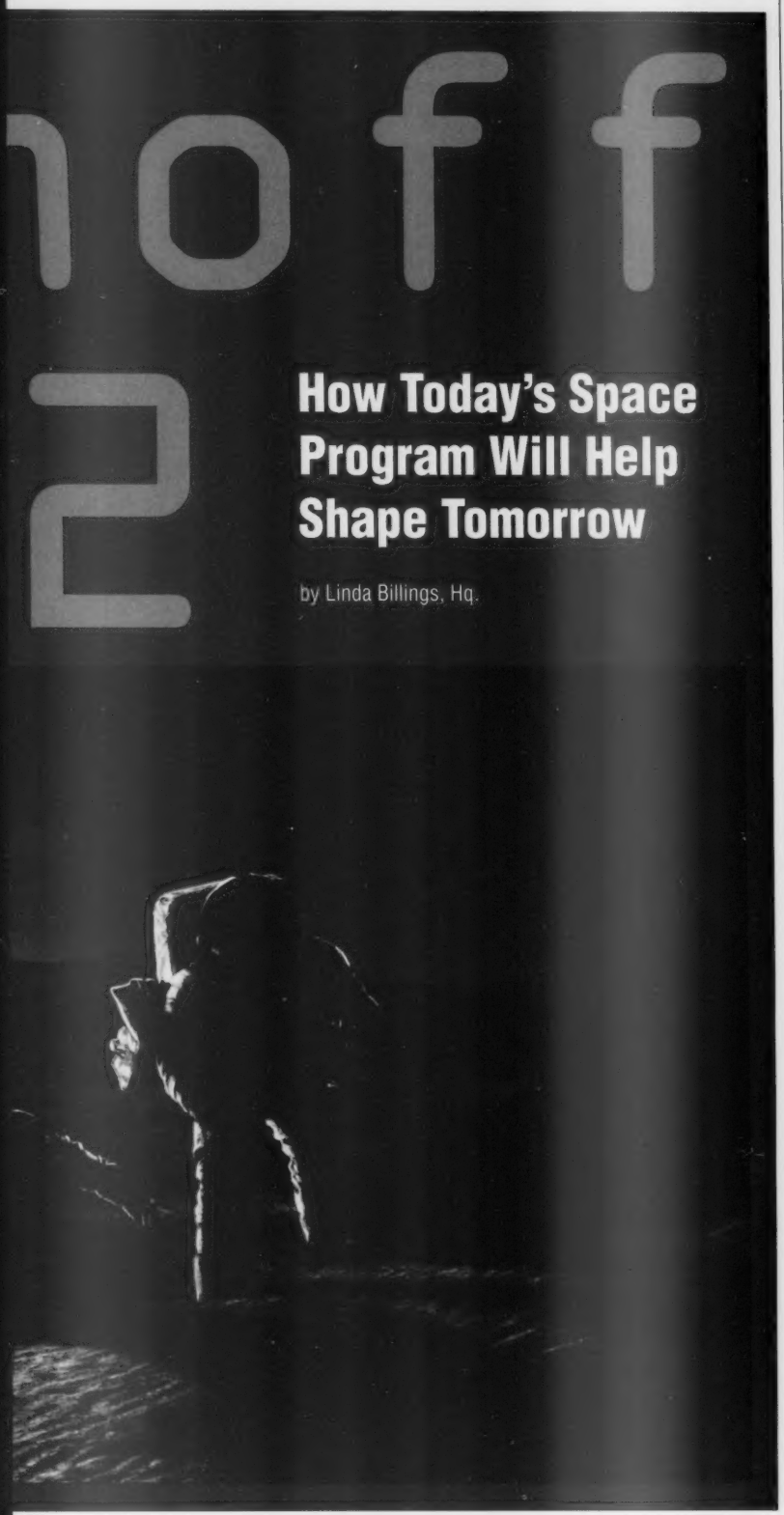
This scenario may seem like pie in the sky, the future seen through rose-colored glasses. In a way, it is. But why not expect a lot? History has shown again and again that no matter how wild our predictions, they look pretty tame compared to reality 50 years later. In 1942, for example, who would have predicted the proliferation of personal computers in the workplace, the home, the classroom, and the market place?

Here, then, are some of the ways people of the 21st century might be reaping the benefits of today's space science and technology programs.

March 20, 2022

Scott Southerlan took off for school a few minutes late today. As he was brushing his teeth, he had heard the beginning of a television news report about the exploration team that had landed on Mars a few weeks ago, and he just had to listen to the whole thing. He had been reminded that today was the day his class would be able to watch a five-minute live broadcast from Mars. He loved to hear people in space talk about the work they were doing there; it really brought to life his computer simulations of chemistry





How Today's Space Program Will Help Shape Tomorrow

by Linda Billings, Hq.

and biology experiments at school. And the scenery was always spectacular.

Scott started running the three blocks to school, but halfway there his telecommunicator beeped. It was his mother telling him he'd forgotten his electronic cash card—she would drop it off later, in time for him to buy lunch. Scott's parents had told him about how when they were his age, they had to look for a phone booth whenever they wanted to call home. If their parents had wanted to give them a message, they left it on a piece of paper taped to the refrigerator door. Scott couldn't imagine how anybody could keep things straight that way.

As he approached the side door of Neil Armstrong Junior High, he checked his telecom for a weather report since he was supposed to play soccer after school....

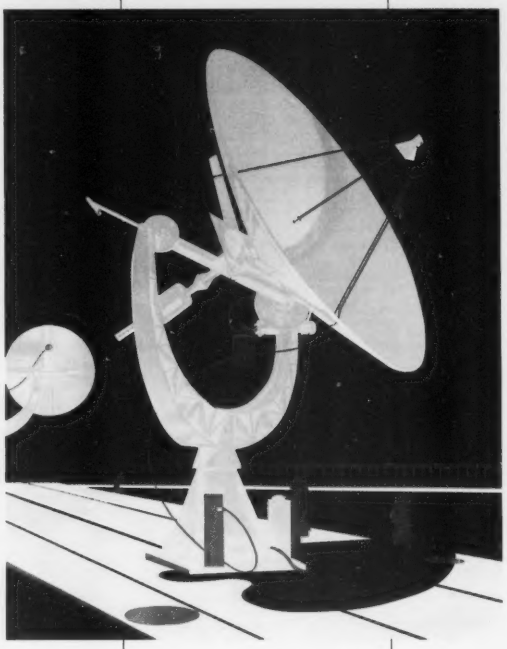
Space-based communications technology now provides a growing array of services—from telephone and video links to data transmission, positioning information, and mobile communications— to customers all over the world. Communications satellites are still rather expensive to build and launch, but the current trend is toward smaller, cheaper satellites and transponders (the devices that receive signals from the ground and relay them back to Earth) that can handle a much higher volume of traffic.

Advanced technology development should continue to lower the cost of communications: the cost of a digital circuit dropped from one dollar in the early 1960s to one-ten-thousandth of a cent by 1990. Before the turn of the century it should drop to one-millionth of a cent.

While costs are plummeting, the processing speed of digital circuits is increasing exponentially. It is not unreasonable to assume that 30 years from now, the cost of transcontinental and transoceanic communications might be no higher than the cost of phoning your neighbor today, thanks to advances in space-based communications technology developed by NASA and the private sector. (Fiber-optic technology will

play a part as well.)

For the cost and trouble of installing a telephone in 1992 (that is, paying a very small fee and plugging a jack into a wall outlet) homeowners in 2022 may be able to turn on a voice/video/data communications service that connects them to a worldwide network. Scott's telecommunicator of 2022—a combination mobile phone, beeper, Day-timer, radio and emergency beacon—will send and receive messages and information via satellite using a smaller scale variation on the Tracking and Data Relay Satellite System launched by NASA in the 1980s. In fact, the space program is a major driver of the microminiaturization of electronics that will enable such a telecommunicator to come into being, at a price low enough that anyone who owns a wristwatch today will be able to own one of these ultramodern conveniences in 2022.

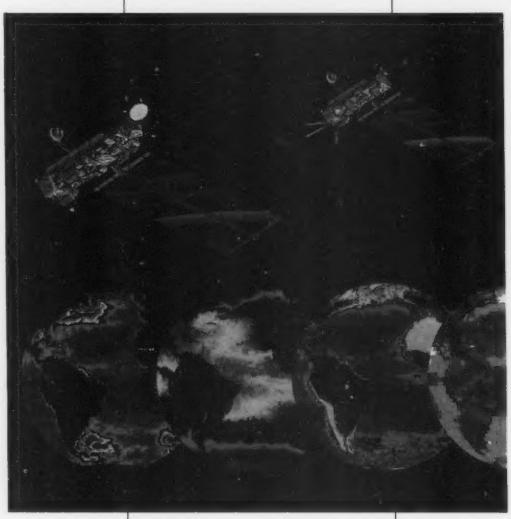


Homeowners in 2022 may be able to turn on a voice/video/data communications service that connects them to a worldwide network.

March 20, 2022

Scott's mother, Susan, went to work as soon as he ran out the door. But she didn't have to go anywhere. It was easy for her to work as a computer scientist at home, in an office equipped with state-of-the-art computer systems as well as a mini-videoconferencing system that enabled her to brainstorm with her colleagues face to face, so to speak, at the drop of an electronic mail message. She remembered when she first became interested in computers, in junior high 22 years ago. Voice-activated computers were just coming onto the market then. Now, of course, almost all computers were voice-activated.

Susan knew that the space program had been at the forefront of advanced computer technology for many years now. NASA always seemed to need computers that were smaller, faster, higher-capacity, more versatile, more autonomous and more user friendly. It was still the case today, she thought; the research lab she worked for was developing advanced virtual reality training simulations for NASA. Looking back, she recalled that microgravity research conducted by NASA in the late 1990s had yielded greater understanding of the process of crystal growth, enabling the U.S. semiconductor manufacturing industry to produce purer and more homogeneous raw materials for better computer chips....



January 1992

Today, private-sector demand for sophisticated data and information systems is growing by leaps and bounds. Technology developed by NASA may ultimately meet much of this demand, since the Agency leads the way in developing new data processing, archiving and storage methods.

By the 1980s, spacecraft had become so sophisticated that they were routinely gathering and transmitting data at rates far beyond our ability to digest the data; hence, NASA's interest in data processing, archiving and storage. Projects such as the Earth Observing System Data and Information System and the Astrophysics Data System will be models of the computerized information systems of the future.

Demand is also growing for ultra-small integrated circuits and ultra-high-speed parallel computing, technologies critical

to U.S. economic competitiveness. NASA's Search for Extraterrestrial Intelligence (SETI) program happens to be pushing the state of the art in this field. In the 1980s, NASA developed and demonstrated the first generation of a SETI multichannel spectrum analyzer (MCSA) that could process 74,000 channels of data simultaneously. A second-generation MCSA has been developed with a 15 million-channel capacity, and some researchers predict that a one billion-channel MCSA will be available by the turn of the century.

The SETI program is also developing two types of very large scale integrated (VLSI) computer chips that are better than anything on the market: a high-speed, high-volume digital signal processing (DSP) chip and a content-addressable memory (CAM) chip. SETI computer technology may continue to lead the market into the 21st century, helping the United States maintain a strong position in an increasingly competitive world.

SETI computer technology may continue to lead the market into the 21st century, helping the United States maintain a strong position in an increasingly competitive world.

JPL's "Goto" roving robot may be the image of microbots to come.

It's expected, however, that digital data processing technology will hit the ceiling of physical limitations on speed and capacity by the turn of the century. So NASA already is researching photonic information transmission—sending messages by light—as a possible alternative.

March 20, 2022

Jim Southerlan had been fascinated with robots since 1995, when his mother and father bought him a videocassette of a great old movie called Star Wars *for his fifth birthday. Through grade school and high school, he'd kept close track of the work NASA was doing in the field of automation. Now he made a living developing smarter, faster robots for industrial applications. He couldn't be happier; he was doing what he'd always dreamed of, and he was especially pleased that his son Scott was so interested in his work. Jim had spent two summers during college and grad school working at NASA field centers in student research programs. He'd worked first with the people who were developing robotic servicing systems for Space Station Freedom, and then with a team designing a flock of mini-rovers to explore the surface of Mars. He still kept in touch with his NASA "mentors," enough to know that they were still coming up with innovations that usually proved to be useful on Earth as well. For instance, in his own job Jim was making some final adjustments to a telerobotic power plant maintenance and repair system that used many of the same elements as a second-generation space station maintenance and repair system NASA had put into operation 10 years ago....*

January 1992

NASA is a leader in the field of telerobotics—robotic systems run by human operators from remote locations. On the Moon and Mars, humans will be able to

remain in a safe, protected place (a lunar base, a Mars lander) while directing telerobots to take pictures, pick up samples, sample atmospheres and surface materials, and measure temperatures, wind speeds and magnetic fields in the hostile planetary environment. Working together, humans and sophisticated machines will be able to accomplish far more than either one could alone.

This telerobotics technology has potential Earth applications in many fields, including agriculture and manufacturing. Hazardous operations in factories, power plants, laboratories, and other facilities all could be conducted by telerobots, protecting humans from contamination and injury.

Researchers are now looking into the miniaturization of robotics technology for space applications; for example, swarms of robotic rovers weighing less than a pound apiece could be used to explore the surface of a planet or repair space stations in Earth orbit. But variations of these "microbots" tailored to Earth applications could fill a variety of other needs as well. Researchers could use them to gather data and samples in hostile environments such as the ocean floor, and factories could use them for heavy equipment monitoring and diagnostics.

"Microbots" tailored to Earth applications could fill a variety of needs, gathering data and samples in hostile environments.

March 20, 2022

Knowing that he'd be able to play soccer after school made it a little easier for Scott to concentrate on his science lessons. He'd checked his telecommunicator again after lunch. Even though the sky was pretty cloudy, no rain was expected to fall in his area until about 6:15 p.m. Last year, he'd prepared a report for his Earth science class on remote sensing from space. He'd found that seasats equipped with seventh-generation coastal zone color scanners and other sophisticated sensors were enabling large-scale aquaculture to thrive (both the fish farms and the seasats were privately owned and operated). He had also learned that a space-based monitoring system now enabled the enforcement of laws established in 2000 to end illegal waste dumping; that 21st century meteorological satellites enabled more accurate and longer-term weather prediction, which had drastically reduced the damages caused by natural disasters; and that enough geologic remote sensing data had been collected by 2015 to complete the detailed mapping of the surface of the Earth and the ocean floor.

New kinds of monitors and biosensors will cut down on expensive laboratory work, doctor's office visits, and hospital stays.

January 1992

NASA's efforts in remote sensing research and technology development have already enriched human lives on Earth. Ocean, atmospheric and land sensors installed on satellites have improved the quality and accuracy of weather forecasting and firefighting, and have enabled global assessments of resources such as arable land, water, forests, fish, oil and minerals. Many businesses already use remote sensing data to improve efficiency and save money. Energy companies use data on land surface structure and rock types to locate oil and mineral resources, and agribusinesses analyze remote sensing data to assess crop yields and stresses.

One major focus of space remote sensing today is ozone mapping and monitoring. It was information collected by NASA's Nimbus 7 satellite that first confirmed the hole in the Antarctic ozone layer. Scientists still do not know for sure exactly what causes variations in atmospheric ozone, but the consensus is that if ozone levels continue to drop, life on Earth will suffer. It's easy to see how all life on Earth will benefit from further knowledge of the causes and extent of ozone depletion.

March 20, 2022

Susan Southerlan's younger sister Jill, a pre-med student at the University of Michigan, called to deliver a progress report. Jill was hoping to pursue a career in biomedical research. One of her professors, now in her 70s, had worked for many years with NASA's space life sciences program before retiring to academia, and Jill was learning a

Annual Report of the LunaSys Corporation, 2022

- Initiated in 2017, began to turn a profit last year.
- Primary lunar products: oxygen, silicon, iron, aluminum, helium-3 and chrome.

Human-tended mining facilities extract oxygen from ilmenite, a mineral found in abundance on the lunar surface, to produce rocket fuel for government and commercial clients. Lunar oxygen has lowered the cost of space operations by cutting the expense of transporting fuels to low Earth orbit—only hydrogen is imported from Earth today. Ilmenite mines also yield water that sells to lunar bases.

LunaSys scientists discovered large deposits of the mineral chromite, a source of raw chrome metal, in 2020. Planetary geologists had predicted the existence of such deposits decades ago, based on what they knew about the common history of the geologic evolution of Earth and the Moon. Since Earth's chromite deposits are virtually depleted and Earth industries still need chrome, LunaSys joined a global consortium of mining companies last year that is already extracting chromium from the lunar regolith for export to Earth.

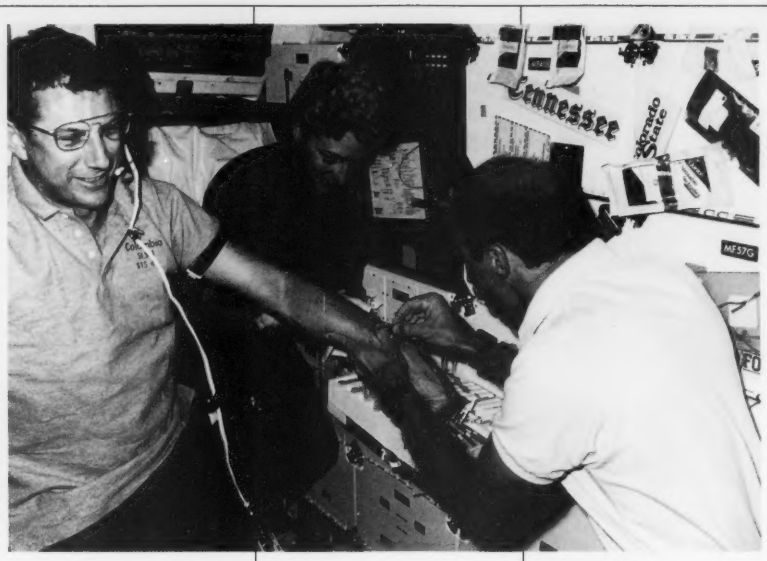
Helium-3, an isotope of helium not found except in trace amounts on Earth, is now being mined as a fuel for fusion power, which finally was harnessed as an energy source in the late 1990s. In 2009, the corporation entered a joint venture with the World Space Development Organization to develop a new mining facility that would extract helium-3 from lunar soil for export to Earth. This plant began operations in 2019. Following more than a decade of research, development, and pilot plant operations, Earth's first fusion power plant, a pollution-free facility built by the European Community, started up in 2020. With this plant as our first customer, the helium-3 project should break even by 2024.

lot from this woman about the medical advances made possible by space research.

During the 1990s, several developments in the space life sciences had contributed to better and cheaper health care for people all over the world. A medical database format developed for use on long space missions had been standardized by a private company and marketed to physicians. Medi-Record was now as popular with doctors as the Physician's Desk Reference; their offices were no longer full of paper files that had been impossible to keep up to date.

The longer duration space missions that NASA began flying in the 1990s were only the precursors for months-long tours of duty on the space station, lunar base stays, and flights to Mars. These long missions gave scientists the opportunity to collect extensive data on human physiological responses to the microgravity environment. The knowledge gained about fundamental human physiological processes enabled medical researchers to solve significant health problems on Earth as well as in space.

Jill knew, for example, that thanks to research into the cause and extent of bone mass loss in space, an inexpensive medication was now widely available to inhibit the development of osteoporosis, a condition causing brittle bones and fractures. Similarly, studies of muscle deterioration in the absence of gravity had provided new insights that helped researchers come up with a way to chemically inhibit the muscle wasting seen in bedridden or otherwise immobilized patients....



Space Lab Life Science 1 mission astronauts conduct biomedical experiments to benefit future space travelers and the Earthbound.

The CELSS program ultimately may yield automated crop production techniques with Earth applications; breeding and genetic engineering of new plants with higher yields of edible biomass; plant growth systems that conserve soil, water, labor and energy; and the production of biochemicals from plants.

January 1992

Today NASA is working on non-intrusive methods of measuring human physiological parameters in space that could be useful to the medical profession here on Earth. For instance, NASA researchers studying space motion sickness have developed a device that a patient can wear to monitor several different physiological responses over an 18-hour day. NASA also is working on implantable biochemical sensors that can be inserted into the bodies of space crew members serving as subjects for biomedical studies. These biosensors are intended to measure concentrations of calcium, sodium, potassium and other ions in the blood stream, and should be of interest to the medical profession here on Earth; in fact, NASA already has found a private company interested in marketing them. New kinds of monitors and biosensors will cut down on expensive laboratory work, doctors' office visits, and hospital stays. Similar biosensors could also be developed for industrial applications—monitoring drinking water and waste water quality, for example.

Another space life science spinoff with potential Earth applications is the telemedicine "spacebridge." NASA first demonstrated this concept in 1989, linking medical specialists thousands of miles apart by voice and video, via satellite, to consult on medical emergencies resulting from natural disasters. Broader application of the telemedicine spacebridge concept would enable physicians and medical researchers all over the world to collaborate on emergencies and other special cases.

March 20, 2022

When Scott got home from soccer, he checked his electronic mailbox and found a letter from his Uncle John, who worked in Alaska for a big agribusiness concern. John Southerlan was a biologist who tended the food crops grown in the big dome just outside Fairbanks. This "Controlled Ecological Life Support System"—CELSS for short—relied heavily on scaled-up versions of atmospheric regulation, temperature maintenance, water recycling, and lighting and nutrient supply techniques originally developed by NASA for space stations and planetary settlements.

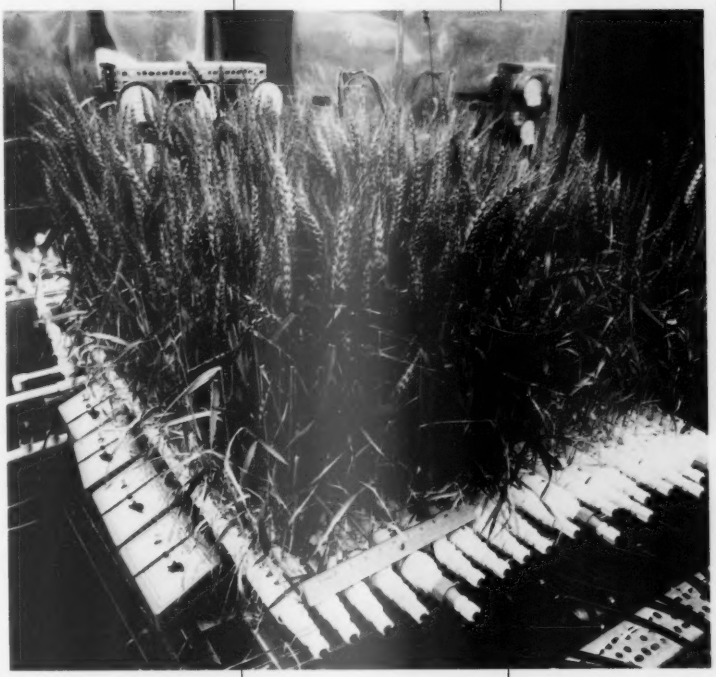
Crops thrived in the dome year round, thanks to highly efficient fuel cells developed originally for lunar base applications, which could store solar energy collected during the summer for consumption during the long, dark winter. The dome enabled Fairbanks to reduce its dependence on expensive imports of fresh food during most of the year.

The whole family had toured "Uncle John's Dome" last year, and Jim had declared it—using an outdated phrase that always made his son smile—"totally radical." In college, John had studied the findings of space gravitational biology experiments that had led to a greater understanding of the mechanisms affecting plant development. The lessons learned had been valuable on Earth as well as in space....

January 1992

NASA's research into CELSS has already produced new information on crops that yield a high percentage of edible biomass, as well as on lighting and nutrient mixes that increase the yield of food crops. NASA researchers are also studying new processing techniques that can convert a higher percentage of plant mass into edible food, and have identified enzymes produced by microorganisms as good means for converting a higher proportion of biomass into food products.

It is not necessarily fanciful to envision a 21st century civilization that has learned to live in harmony with technology and to use that technology to protect the home planet, improve and equalize our quality of life and make other planets hospitable to humans.



The Controlled Ecological Life Support System produces a bumper crop of wheat in an experiment at Kennedy Space Center.

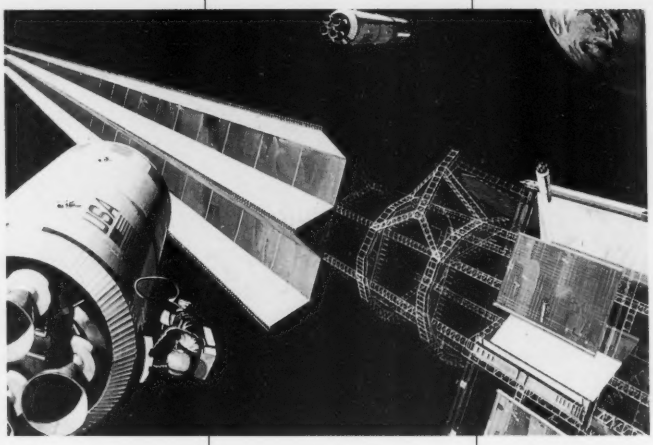
Researchers also are at work on a high-efficiency CELSS lighting technique that uses light-emitting diode (LED) arrays for plant growth chambers. LEDs can be manufactured to give off all their light in regions of the spectrum that promote plant growth, rather than converting most of the energy to waste heat. The CELSS program may ultimately yield automated crop production techniques with Earth applications; breeding and genetic engineering of new plants with higher yields of edible biomass; plant growth systems that conserve soil, water, labor and energy; and the production of biochemicals from plants.

March 21, 2022

Today was the day Scott had to turn in his report on U.S. energy production and consumption over the past 100 years. Uncle John had helped by sending him information on the state of the art in energy production. Solar power satellites, studied since the 1970s, had finally come into being in 2008, and now provided clean, cheap, renewable power to people on Earth. The system launched in 2008 collected sunlight by a huge array of solar cells, converted the solar power to microwave energy and

beamed that energy back to Earth for conversion to electricity and distribution throughout the power grid. Ever since the first solar power satellite system was launched, NASA and the Department of Energy had been working together on plans for using lunar resources to manufacture follow-on systems in space.

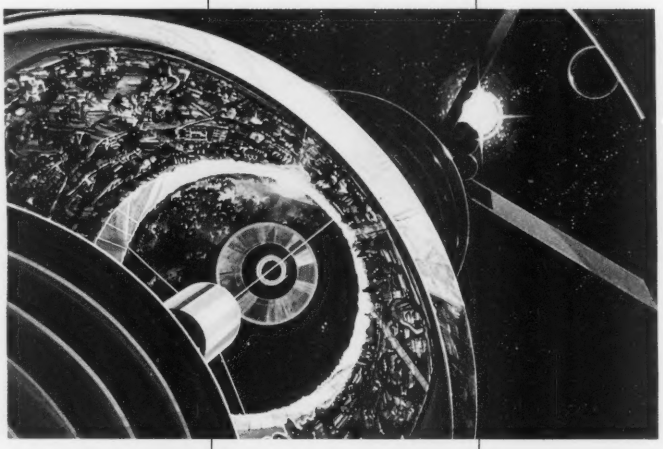
At lunchtime, Scott talked with his friends about what he wanted to do on his spring vacation next month. His family was planning a trip to an Earth-orbiting space hotel. The place was more like a campground than a glamorous spa, and it was expensive. But his mother and father were as excited as he was about the prospect of spending three days in space, observing the Earth and playing amateur astronomer. The flight to and from the hotel alone would be almost worth the cost....



Solar power satellite systems may beam energy to Earth to meet the energy requirements of the 21st century.

January 1992

Will the future be as positive as it's made out to be here? William Gibson's seminal cyberpunk novel *Neuromancer* and Ridley Scott's brilliant film *Blade Runner* both envision a future world—it could be 2022—in which genetically engineered human body parts are grown in vats and sold like shoes, people can connect their brains to an electronic "grid" of computerized information that can reveal everything about anything, and technology pirates roam the globe, selling their booty to the highest bidder. In this world, technology reigns supreme, but it doesn't necessarily benefit humankind. Gibson's and Scott's world of the future is an ominous place, where a few select people understand and control technology and, hence, hold power over everyone else.



Technological progress can be a scary prospect, but it is also the way we have improved the quality of our lives from generation to generation. Science and technology are not inherently good or bad. It matters more what we do with what we learn. It is not necessarily fanciful to envision a 21st century civilization that has learned to live in harmony with technology and to use that technology to protect the home planet, improve and equalize our quality of life and make other planets hospitable to humans.

All of this may turn out to be far from the mark. But the point is that we are now capable of realizing much of the vision. We can look forward to a future in which space exploration continues to spur the scientific and technological progress that helps ultimately to solve global problems on Earth and broaden our intellectual horizons. ●

Linda Billings is co-author of the book *First Contact: The Search for Extraterrestrial Intelligence*, a former senior editor for *Air & Space/Smithsonian* and space editor for *Space Business News*. She is currently a senior writer for BDM International supporting NASA programs.

Headlines Into the Next Century

Identification of the Missing Matter that Makes Up 90 Percent of the Universe's Mass

Gravitational Waves Detected

Source of Huge Energies in Exploding Galaxies Discovered

Image of the Immediate Surroundings of a Black Hole at the Center of Our Galaxy

Amino Acids Discovered in the Uranian Ocean

Supernova Debris Recovered from Comet Ice

Methane Volcanoes Discovered on Pluto

First Planet Discovered Outside of the Solar System

Signal Detected from Extraterrestrial Intelligence

Monthly Solar Flare Predictions Accurate to Within Hours

Links Between Solar Activity and Our Weather Understood

Earth's Entire Radiation Belt Imaged

Monthly Hurricane Predictions Accurate Within 12 Hours and 100 Miles

Three Consecutive Earthquakes Predicted with 24-Hour and 50-Mile Accuracy

Space Station Project Team Celebrates First Year Within a Synthetic Biosphere

Bone Thinning in Astronauts Halted with Treatment Applicable to People on Earth

Perfect Gallium Arsenide Crystals Produced in Space Station

Thirty-day Weather Forecast Now 95 Percent Accurate

New State of Matter Produced in a Space Laboratory

Ices Discovered at the Lunar Poles

Fossils Found in Ancient Martian Riverbed

Venus Volcanoes Verified

—from The Report of the National Commission on Space, Pioneering the Space Frontier, 1986.

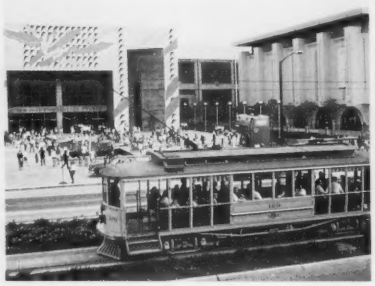
Technology A Tech Bazaar for Business

Attention, shoppers: The future is now.

Climbing robots, a recycling system that eats junk and spits out three-dimensional products with decorative coverings, and a 600-horsepower supercar with the credentials of a rocket were among the items on hand at the Technology 2001 conference and exposition held at the San Jose Convention Center in early December.

Sponsored by NASA, the Technology Utilization Foundation and NASA Tech Briefs magazine, the gathering was designed to call private business's attention to the $65 billion technology bank the U.S. Government has available for their use. The three-day meet showcased work underway at more than 50 federal laboratories belonging to NASA and 10 other federal agencies, including the Environmental Protection Agency, the National Science Foundation, and the Departments of Agriculture, Commerce, Defense, Energy, Health and Human Services, Interior, Transportation, and Veterans Affairs. Also joining the exhibit were more than 150 companies and universities with technologies available for license or sale.

NASA has taken the lead to encourage the transfer of federal



Technology 2001 helps share government technology at San Jose, California meet in December.

2001

The Vector automobile uses space technology for high performance.

technology to the private sector, and Technology 2001 showed the support Government agencies can bring to this kind of information sharing. Top federal tech transfer experts were on hand at the meet to show business leaders how to tap into Uncle Sam's R&D storehouse.

The conference included workshops and technical sessions led by experts in fifteen critical areas of technology ranging from artificial intelligence and biotechnology to data and information management, robotics, software engineering, electronics and electro-optics, and test and measurement.

A sampling of the technologies on display included:

—A refrigerator that doesn't use ozone-depleting chlorofluorocarbons (CFCs). The "thermoacoustic" space ice-box uses high amplitude sound in inert gas to pump heat. It has only one moving part, and the parts that don't move are inexpensive. Its performance compares to current refrigerators, making it a good candidate to be the refrigerator of choice for an ozone-conscious society.

—A new type of child's lunchbox—a microwaveable urethane foam insulation container that can keep a prepackaged meal warm for up to five hours—traces its heritage to thermal protection systems used on the space shuttle's external tank.

—A new NASA-developed ion-selective electrode that non-invasively detects ionic calcium to measure bone loss during space flight as well as during hospital immobilization on the ground. The device could be a boon for osteoporosis researchers.

—A "Data Egg" that handicapped computer hackers can use for one-handed text entry. The egg can be operated from any position, autonomously or connected to the hardware.

—A worm-like cable robot that moves up and down, back and forth and upside down, thanks to magnetic feet that allow it to climb or adhere to tall metal structures. The robot could be equipped with TV to inspect, clean or paint towers, tanks, bridges, and even ships.

—Thermoplastic capsules for sealing hazardous wastes such as nitrate salt and incinerator fly ash, which offer improved methods of complying with hazardous waste disposal regulations.

This device eats junk but produces products like interior car door panels.

—A new imaging radiometer using gallium arsenide technology that can locate hot spots, whether they're found in small electronic circuitry or in erupting forest fires. The detector also is applicable to medical thermal imaging.

Rocket technology is brought down to Earth for U.S. business.

For business executives making the rounds at the Technology 2001 conference, workshop sessions were held on patent licensing, cooperative R&D agreements and Small Business Innovation Research contracts.

Technology 2001 tripled the attendance at last year's Tech 2000 conference, which was held in Washington.

Meanwhile, says Leonard Ault of NASA's Technology Utilization Division, Office of Commercial Programs, the agency is working to further improve its tech transfer program. In April, NASA initiated a five-year development program to establish the National Technology Transfer Center as a resource for Federal technology transfer. And beginning this month, six new Regional Technology Transfer Centers will replace NASA's Industrial Applications Centers to upgrade the agency's tech transfer effort for the 1990s and beyond. •

Help for the Human Body

NASA technology has contributed to more healthful living since the earliest days of the space age. Pacemakers, implantable devices for dispensing insulin in diabetics, multi-patient hospital monitors and medical imaging devices such as the CATSCAN and Magnetic Resonance Imager (MRI) all trace their technological ancestry to NASA programs. As new applications emerge, the re-use of space technology continues to benefit all of us, healthy and unhealthy alike.

Diagnosis and Treatment of Burns

Each year, 70,000 Americans suffer burns that require intensive care. A new ultrasound system using technology originally developed to detect flaws in aircraft and spacecraft materials is now being used to assess burn damage for quicker healing.

The depth of the burn is the critical factor in treating second and third degree burns. Effective treatment depends on early recognition of the extent of dead tissue and its removal by chemical or surgical means to minimize risk of infection and hasten healing. Langley Research Center developed a prototype instrument that's capable of determining where burned tissue ends and healthy tissue begins by detecting density differences. The result is the Supra Scanner. Developed by Westminster Supra Scanner, Inc., and produced under NASA license, it's the first clinically tested, commercially available system of its kind.

Heart Research

Researchers at the University of Pittsburgh School of Medicine are now developing a computer model to help scientists understand stress and strain in the heart. While MRI provides full 3-D views of the heart's surface, the researchers wanted a way to visualize and track material within the heart muscle using an implantable marker. Unfortunately, no solid or gel would do the trick—what was needed was a very small (about two millimeters in diameter), yet tough "egg" containing a solution of copper sulfate.

When efforts to fabricate such an egg failed, the Jet Propulsion Laboratory provided the Pittsburgh researchers with a complete set of reports on methods of microencapsulation. In one of the reports—describing an apparatus for producing hollow spheres—the heart researchers found the solution to their problem.

The Pittsburgh School of Medicine has since conducted a series of MRI animal heart imaging tests, and is using the information provided by the markers to compute strains and associated stresses. The research is expected to lead to improved understanding of how the heart works (and fails), which may in turn lead to improved techniques for detecting and treating heart disease.

High-tech thermometer provides speed, accuracy, comfort.

Fast Response Infrared Thermometer

What weighs only eight ounces, can be operated with one hand and measures temperatures in less than two seconds? Answer: A new kind of infrared thermometer that's ideal for taking the temperature of newborn infants, critically ill people, and others who are incapacitated.

Approximately one billion clinical temperature readings are taken in acute care hospital facilities annually in the U.S. alone. Diatek Corporation saw a need to reduce nursing time by providing a faster thermometer, so the company turned to infrared optical technology, which measures the energy emitted from the eardrum into the ear canal. Along with being fast and accurate, the approach obviates the need for oral or rectal readings and avoids contact with

mucous membranes, virtually eliminating the possibility of cross-infection.

Diatek began work on designing its infrared sensor, but soon found a need for expert guidance. JPL's 30 years of experience in measuring infrared emissions from distant stars and planets turned out to be just what the company needed. Diatek and JPL worked closely together to develop the infrared sensor that is the heart of the Diatek 7000 aural thermometer. As a result, clinical testing of the thermometer was completed in 1990, and the device went on the commercial market in 1991.

Spinal Bracing

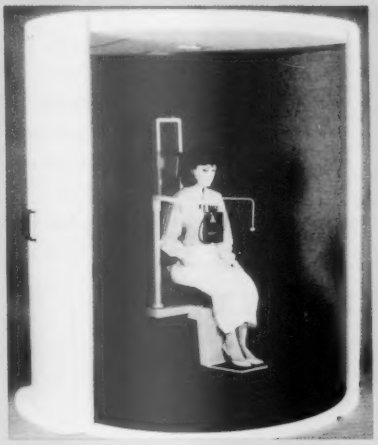
A few years ago Sandra Wafer's dream of becoming a ballerina seemed quite remote. A victim of scoliosis, she suffered from a progressive curvature of the spine. But a new treatment focusing on innovative bracing techniques as an alternative to surgical correction helped Wafer escape the deformities of her disease and go on to become a dancer with the City Ballet of Houston.

The Copes brace aids recovery from scoliosis.

The key element of the treatment is use of the Copes Scoliosis Brace, which features a novel pneumatic bladder that exerts corrective pressure on the spinal curve. The brace may have as many as six bladders, each containing a valve system to alter pressure as needed. Orthotist Arthur Copes' treatment involves long-term use of the brace, along with exercise, hydrotherapy, bone manipulation and muscle stimulation. In developing his brace, Copes used more than 50 technical reports from NASA's databank and other sources to investigate different braces and materials. He notes that the NASA data contributed significantly to the creation of a device that has had extraordinary results in hundreds of patients.

Balance Function Disorders

Balance disorders affect more than two million Americans annually. In about 20 percent of these cases, the problem results from inner ear disease that can cause vertigo, whirling or dizziness. At the Minneapolis Neuroscience Institute, physicians and researchers are using a rotating chair originally developed to investigate the inner ear functions of astronauts spinning in weightlessness.



Microgravity spin chair is used in balance disorder research.

"The chair technology is invaluable for assessing balance function problems," says Gene Balzer, an audiologist and clinical researcher. "It is particularly helpful in my research with deaf and blind individuals who lack vestibular (inner ear) function, a group that could not adequately be evaluated with previous testing technology. Chair testing can also be used to evaluate children under the age of two, something that was difficult with other tests."

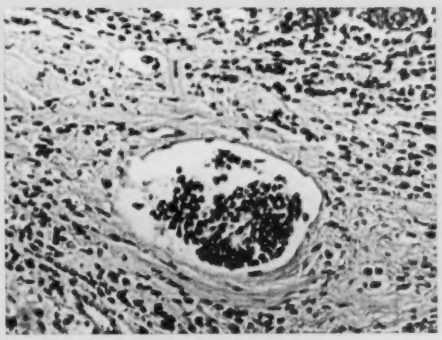
The chair also is used to diagnose patients with Meniere's disease (abnormal fluid buildup in the inner ear) and for older patients where the loss of vestibular function is difficult to detect. Other uses include monitoring patients recovering from removal of tumors on the acoustic/vestibular nerve, and helping researchers find ways to overcome post-operative dizziness.

Medical Imaging System

Using a descendant of software originally designed for analysis of Landsat satellite images, Crystal Image Technologies, Crystal Data Systems and Delta Technologies have developed a true-color image processing system to aid in the diagnosis of cancer and other diseases.

The MD Image System includes a microscope, color video camera, a computer and a workstation for image processing, data storage, and data communications. The software is a proprietary version of a NASA package that helps the user recognize patterns. Generally, the system acquires microscope-based images, performs statistical analysis on them, stores them in standard database format, and transmits them to other remote sites for consultation.

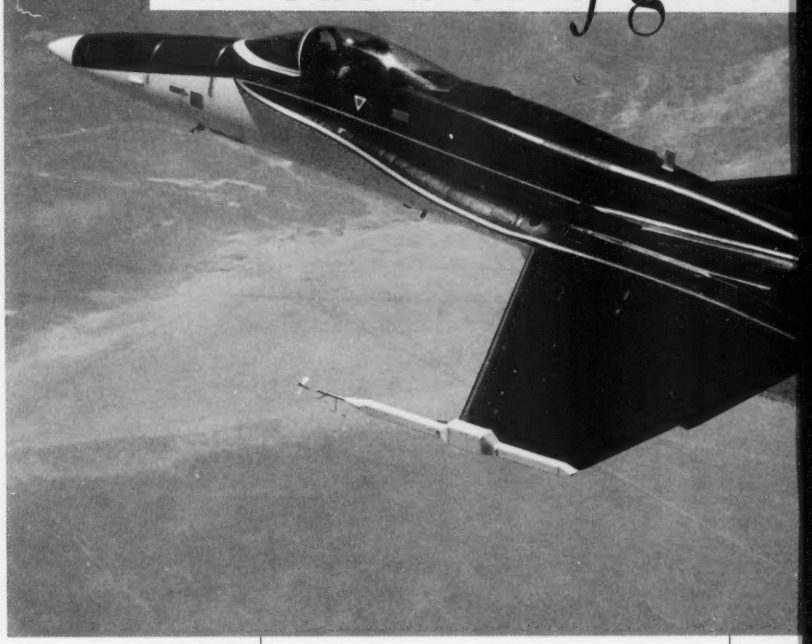
The system can accept, store and analyze images from other sources, such as those from an MRI system, and these images can in turn be attached as records in the common database format. They may then be combined for a complete patient image database from multiple sources, such as pathology, radiology and cardiology. ●



Landsat derived software was a beginning for medical imaging system.

19

It was a very good



The past year was filled with dramatic variety. It was a year during which NASA made fundamental changes in organization and program content, yet did so without missing a beat in conducting the nation's vibrant aeronautics and space program.

Under the leadership of Administrator Richard H. Truly, NASA moved out aggressively to implement recommendations by the Committee on the Future of the U.S. Space Program and to examine the space exploration options offered by the Synthesis Group. Working with his senior managers at NASA Headquarters and field centers, Truly undertook an extensive agency reorganization while carefully considering the potential impact on people, operations and safety. He also charged the NASA program offices with restructuring the development and funding of several large projects, including Space Station Freedom and the Earth Observation System.

Here are a few of the scientific, aeronautical and engineering developments accomplished this year.

In the world of science...

Hubble Space Telescope completed its first year of operational observations with several major scientific discoveries. NASA also announced that it would repair or replace aging or failing gyroscopes and solar panels on the spacecraft and would install a set of corrective optics and at least one replacement instrument on a scheduled shuttle maintenance mission in 1993. Among Hubble's discoveries was a very massive star in the Large Magellanic Cloud that is shedding gases at an exceptional rate and that scientists predict will go supernova within the next few million years. Hubble astronomers also took the first true color photograph of Jupiter.

NASA and the National Science Foundation signed an agreement to conduct research in the dry moraine frozen lake regions of the Antarctic. NASA will build a testbed experimental station which will employ technologies potentially applicable on either the Moon or Mars.

Researchers associated with the Long Duration Exposure Facility reported that the space environment within Low Earth Orbit was harsher than predicted when they discovered the presence of Beryllium-7 in abundances totally unexpected. Beryllium-7 now joins atomic oxygen as a corrosive element of concern to spacecraft designers.

NASA and the Soviet Union teamed together to launch an ozone measuring instrument on a Soviet weather satellite. Satellite data from both NASA and Soviet satellites also indicated that 1991 was the third consecutive year of severe ozone

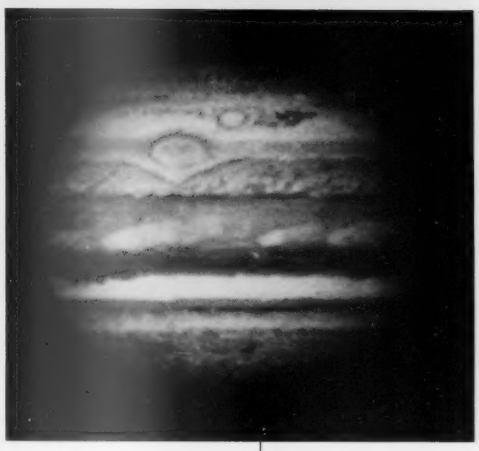
91

year

by Charles Redmond, Hq.

depletion over the Antarctic. NASA also conducted the third in a series of airborne atmospheric investigations into ozone depletion, this time over the Arctic region.

Proving that Venus and Earth are not altogether that unique, Ames scientists announced they had discovered an anti-greenhouse effect taking place on Saturn's primordial Earth-like moon Titan. (See page 28, "Titan: The Moon That Would Be a World.")



The Hubble Space Telescope provides a year of major scientific discoveries and its first true color photograph of Jupiter.

Magellan proved to be a super-achiever and finished its first complete Venus orbiting phase early and began its second phase with only 16 percent of the planet remaining unmapped. Data from the first cycle showed Venus was venting interior heat through giant hot spots. The science team also reported that they had discovered what appears to be a lava flow—observed by comparing changes between the cycle one and cycle two maps.

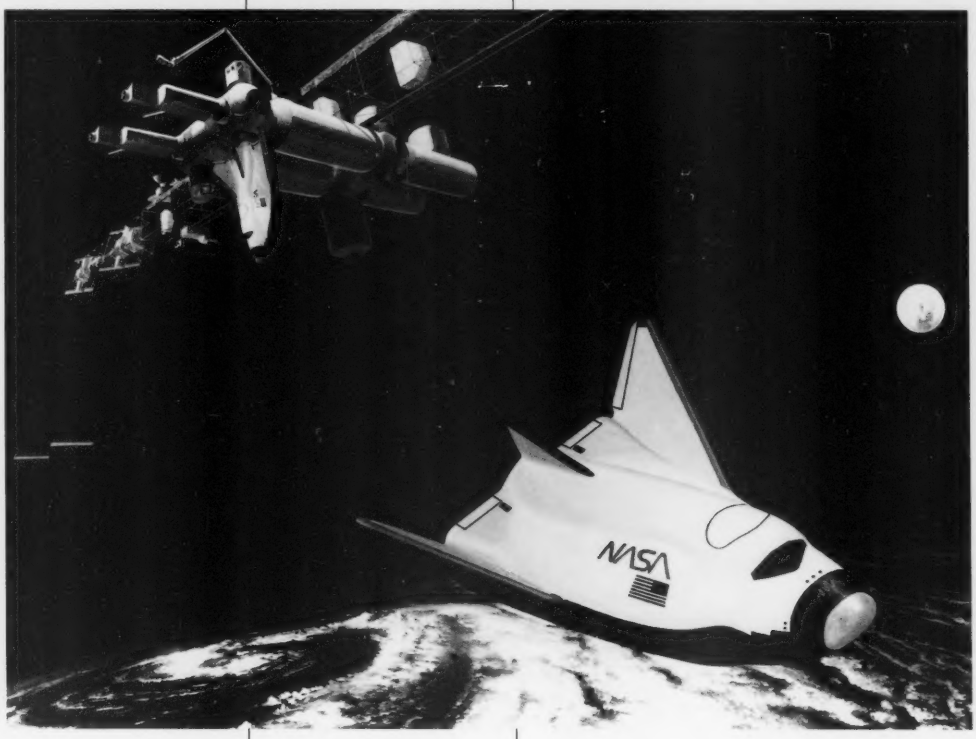
Gamma Ray Observatory Burst and Transient Source instrument team members reported they have been observing an inexplicably high number of such sources which appear to be distributed evenly through the sky. This discovery throws out the previously-held theory that the bursts were associated with the center of the Milky Way and leaves scientists puzzled as to whether the bursts are nearer or farther than thought, or whether they might even be a new type of astrophysical event.

Using a combination of satellite data and ground-site core samples, NASA investigators at Ames and JPL announced they had the first surface evidence for the impact of the comet or asteroid thought to be the cause of the dinosaur extinction. The

discovery is of a ring, more than 125 miles in diameter, centered on Mexico's Yucatan peninsula with portions in the Gulf of Mexico. The satellite images showed evidence of a giant ring structure; the core samples detected deposits dating to 65 million years ago, the time period associated with the dinosaur disappearance.

Life Scientists reported on the results of their first dedicated shuttle research mission and said their findings confirmed that blood volume changes do occur but there is a significant role in those changes being played by the kidneys. Other new findings included empirical evidence, from a catheter inserted in payload specialist Drew Gaffney's arterial system, that cardiovascular change begins to occur on the launch pad—much sooner than had been expected. Another revelation, based again on pulmonary empirical evidence from onboard experiments, was that gravity apparently plays no role whatsoever in lung function.

Galileo flew by the asteroid Gaspra at a range of 1,000 miles, making it the first spacecraft to reconnoiter this family of Solar System objects. Gaspra is 7 by 10 miles across, quite irregular and with an apparent smooth surface of finely ground asteroid soil.



The HL-20 lifting body is one of two concepts being studied as a space station era crew launch system.

NASA presented a restructured Space Station Freedom plan to Congress as a part of its fulfillment of many of the various recommendations presented to the Agency during the previous year.

Air Force and NASA plasma physicists engaged in a series of active release experiments with their Combined Release and Radiation Effects Satellite, resulting in confirmation of some of the theories concerning how Earth's magnetic field lines trap solar radiation.

In the world of space flight...

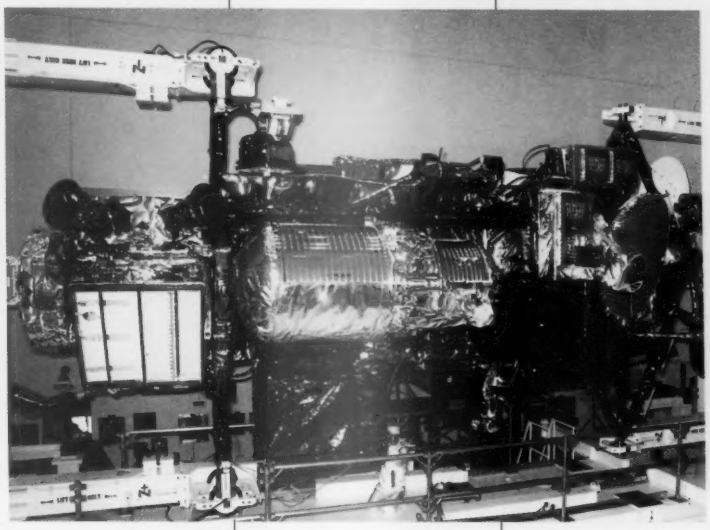
NASA launched six shuttle missions, deploying five spacecraft as part of the year's shuttle program. Two of the spacecraft deployed by shuttle missions were scientific satellites—the Upper Atmosphere Research Satellite and the Gamma Ray Observatory. Several of the missions featured space station technology experiments including some conducted outside the cabin with space-suited crewmembers. The agency also celebrated the tenth anniversary of the first shuttle flight by hosting a series of open houses and technical and scientific seminars around the agency's facilities. The open

house activities were followed shortly by the delivery of the newest orbiter vehicle—the shuttle Endeavour. Endeavour was delivered by Rockwell's Space Division on time and under budget and is currently scheduled for the Intelsat VI satellite repair mission this summer. At the end of last summer, nearly ten-and-a-half years after its first flight, Columbia was flown back to the Rockwell facility for its first major overhaul.

The agency announced that it would form a task force in concert with the Air Force to assess heavy lift launch technologies and options for developing potential launchers. As part of the NASA portion of the joint program, NASA let half-million dollar contracts to three aerospace companies to begin the definition phase of the National Launch System.

NASA presented a restructured Space Station Freedom plan to Congress as part of its fulfillment of many of the various recommendations which have been presented to the agency during the previous year. The new plan calls for assembly of the space station in 1996 with a man-tended capability the next year. The restructured station, though smaller and therefore less costly, still will focus its capabilities on life science and microgravity experimental operations and will be equipped with appropriate hardware to carry out these requirements.

NASA and the Soviet Union also signed agreements to expand civil space cooperation by flying an American aboard a Soviet Mir space station mission and by flying a cosmonaut aboard a shuttle mission.



Technicians prepare the Upper Atmosphere Research Satellite for launch at Kennedy Space Center.

Endeavour was delivered on time and under budget and is currently scheduled for the Intelsat VI Satellite repair mission this summer.

In the aeronautics and space research arena...

NASA's F/A-18 High-Alpha Research Vehicle flew over Edwards Air Force Base this summer and used the thrust vectoring system in flight for the first time. The flight occurred at 32,500 feet and was described by pilot Ed Schneider as being very smooth.

Langley engineers began human factor studies on a full-scale engineering model of the HL-20 lifting body. The HL-20 is one of two designs being considered as Freedom-era crew launch systems.

Langley researchers also completed two flight tests of an airborne windshear test system using NASA's modified Boeing 737 as the flying instrument system and performing a series of landing approaches at the Orlando and Denver airports. The system uses both ground, airport-based doppler radar systems and an onboard wind detection and wind shear radar system to give the flight crew realtime local wind information. NASA is working to characterize the effectiveness of the various detection technologies.

Ames continued its research activities using supercomputers by dedicating their new Biocomputation Center. The center will undertake a study of the three dimensional makeup of a biological neural network in the hope of discovering the underlying principle behind how the nervous system actually works. •

Charles Redmond is Contributing Editor of *NASA MAGAZINE*.

A Marriage Made

This high-flying husband-and-wife team helps NASA push the boundaries of flight.

Synergy. Dissimilar individuals putting their heads together to come up with a better mousetrap.

Some historians say it made the Wright brothers aeronautical geniuses. It makes Bob Meyer and Marta Bohn-Meyer of the Dryden Flight Research Facility two of the best flight test engineers in the airplane business.

"I tend to solve problems from an operations standpoint, trying to be down with the nuts and bolts" says Marta. "Bob, with his research engineer background, steps back and says 'Hey, let's see what the research implications are.' So we end up integrating our ideas to maximize the results."

Over the years, the Meyers have flown as backseaters in some of Dryden's hottest aircraft. Their current flight assignment: Operate research and communications instruments while hurtling through the sky at more than three times the speed of sound aboard NASA's newly acquired SR-71 "Blackbirds."

Airplanes have dominated Bob and Marta's lives. She first flew at 14, soloed at 16. In 1976, as a fledgling engineer, he putt-putted in his Pitts Special biplane cross-country from Dryden in California to the Langley Research Center in Virginia to work with famed aerodynamicist Richard Whitcomb.

It was at Langley that Bob met Marta, then a co-op student from Rensselaer Polytechnic Institute. They found their mutual interest in flying slowly brought them closer together. When they eventually decided to jack the relationship up a notch, the choice of activity was a natural.

They went to the airport to look at Bob's airplane.

"You could say that was our first date," Bob recalls. "I couldn't take her up for a ride, though—it was a single seater. We've since found that we don't fly real well together anyway. It's like having two drivers

Bob Meyer prepares for high altitude chamber training.

Meyer inspects SR-71 cockpit at Dryden Flight Research Facility.

In The Heavens

by Les Dorr, Jr., Hq.

High altitude chamber training prepares NASA's back seat flight test engineers for flights above 80,000 ft.

Marta Bohn-Meyer displays her alternate office, the SR-71 simulator.

in the same car."

After her graduation in 1979, Marta took a full-time engineering job at Dryden, where Bob had returned after a two-year Langley stint. Her career decision was motivated partly by her passion for Bob; they had already decided to marry. But her passion for airplanes was an equal factor.

"I went directly to [NASA test pilot] John Manke, who was running the flight operations division. I told him one of the reasons I came out here was because I wanted the opportunity to fly," says Marta. "He said he'd support me."

"There's just not much that you could do in an airplane that's going to bother us."

The prospect of carving out a niche in a profession dominated by men didn't faze Marta Bohn-Meyer. Indeed, she never thought of the challenge in those terms. She was used to flying as an equal with male pilots, and it hadn't occurred to her until she was a senior in college that people might treat men and women differently in a competition for employment.

"I'm aware now that a qualified woman in the culture we have in the United States today is sometimes going to get a break," Marta says, "but I don't see that it's been either a positive or a negative factor for me. My goal has always been to be the best anyway."

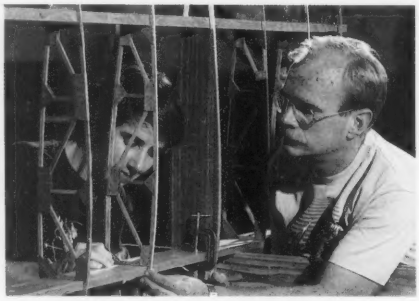
"I suspect there are some cases where I have to try a bit harder because people aren't as willing to let me move in," she continues, "but I think there also have been cases where someone's given me a shot because they thought it was novel and interesting to see a woman doing this kind of work."

Fortunately for both Meyers, Dryden's premier flight test engineers in the late seventies were winding up their careers. Vic Horton and Ray Young, veterans of many NASA high-performance research programs, gave Marta the opportunity to fly missions that they either didn't want or were up her alley. They provided Bob with the same chance after he successfully argued that he could get even more and

better quality data from the flight experiments he'd designed if he rode along.

The Meyers were tapped as the prime backseaters for NASA's research with a specially modified F-14A fighter, from 1984 to 1987. The goal: Find ways to obtain smoother airflow over an airplane's wings. Bob was the principal investigator for the experiment. Marta was the operations engineer responsible for setting up the plane for the flight tests. She remembers that they applied their unique synergy to the program even then.

"When Bob was in the air, I conducted the flight from the Dryden control room, and vice versa. Both of us knew the airplane itself and the reason for the experiments very well. We built up a support structure between the two of us and the other flight crew members to make sure the research was conducted in a safe and orderly manner."



Vocation and avocation: The Meyers relax by building airplanes.

Cooperation between members of a flight research team isn't remarkable. But there's usually a sense of competition, a tendency not to share all the little tricks of the trade that may give someone else an edge in performance.

Neither Marta nor Bob feels that way. They say because they're husband and wife, synergy is second nature to them. They share information without a thought that one of them might profit at the other's expense.

"We spend a lot of our own time talking about our trials and tribulations and trying to come up with a plan of attack to resolve them," Marta explains. "We're used to exposing ourselves to each other, so it's easier to say, 'Hey, I didn't do that very well, try it this way,' or 'Hey, don't do it your way, trust me that this will work better!' "

When NASA and the Air Force started discussions on the loan of several SR-71s, Marta and Bob were named as flight test engineers for the program, should it materialize. But it was also possible that, for expediency, NASA might decide instead to bring in Air Force officers already qualified to run the ex-reconnaissance aircraft's systems. So The Meyers took the initiative to make sure they would be in the rear seat when the sleek, high-flying Blackbirds lifted off the runway in NASA markings.

As soon as an SR-71 simulator arrived at Dryden, they juggled their schedules to grab as much time in the trainer as possible. Bob and Marta also corralled several former Air Force SR-71 crew members at neighboring Edwards Air Force Base to help them learn the Blackbirds' systems. The blue-suiters put them through their paces in the simulator once a week for three to four months.

"When flying the airplane became a reality, there was no question that we were ready to do the job," Bob says matter-of-factly. "We each had somewhere between 150 and 200 hours in the simulator."

Part of the respect and capability that earned the Meyers a slot in the SR-71 program stem from their private flying. In their spare time, they jockey a Pitts Special biplane—their third—in competition aerobatics. Both won California Championship titles in 1990.

The Meyers admit there's no direct correlation between the twisting, high-G maneuvers they perform in competition and the straightforward (but much faster) climb-and-cruise of a research flight. It's more, they say, a matter of being "comfortable" in an environment that isn't naturally familiar—whether it's the cramped cockpit of the Pitts or the back-seat "office" of a high-performance aircraft.

They also garden, run, ski, hike, share their life with other friends.

"I think it makes the flying part of our work something that's not difficult to do. It just makes us accept, 'OK, we can fly in the airplane, let's deal with the job at hand," Marta says.

"There's just not much that you could do in an airplane that's going to bother us," adds Bob.

It shouldn't be surprising that the different methods Bob and Marta bring to their NASA jobs creep into their aerobatic flying as well. Marta is a seat-of-the-pants pilot: "Just tell me if my lines are straight the way they're supposed to be. I don't have to know why you need to put the control stick exactly in a certain position," she says. "Before Bob tries a maneuver, he wants to figure out where the controls have to be and why to make the figure look correct for the judges."

Aerobatic champions and their Pitts biplane.

But she quickly inserts a semi-synergistic spin: "Both approaches obviously work. We both bring home trophies."

On October 3, Marta took her first flight in a real SR-71, the twin-cockpit "B" model that Dryden employs as a pilot trainer. She admits that she was "grinning from ear to ear" before the plane ever left the ground.

As Marta and NASA pilot Steve Ishmael climbed toward their intended altitude of 80,000 feet and speed of 2,130 mph, her task was to run the Blackbird's navigation equipment, call out items on the flight checklist, and communicate with air traffic controllers and the NASA control center at Dryden. It was an extremely busy time, and despite her extensive training Marta fell behind schedule.

"What's interesting is that I caught up with the airplane at an event that I had never physically experienced in the simulator. That's the 'dipsy,' where you push the nose down, accelerate through the transonic region [.8 to 1.2 times the speed of sound], and then pull the nose up again. It took that pushover for me to say, 'I know exactly where we are; I'm back on track and on top of things.'"

After the picture-perfect flight came the exuberance of success ("The victory celebration in auto races has nothing on me!" Marta chuckles) and one helluva party. But true to form, the next morning the Meyers were back at work hashing out Marta's experiences so that Bob's first Blackbird mission would come off like clockwork.

"I gave him some ideas on things that I didn't think were the best, and we went right down into the simulator to see if we could make it a little bit better," says Marta.

It paid off on October 9. Bob kept up with the workload as project pilot Rogers Smith throttled up the Blackbird en route to the stratosphere. Bob found he could even take some time out to analyze what was happening around him.

"The really impressive thing about the SR-71 is nothing you ever see in the simulator," Bob says. "Most airplanes run out of gas around Mach 2 [about 1300 mph], but this plane just keeps on going; it keeps on climbing and accelerating. Even when you get up to cruise conditions, the aircraft feels like it's happy to go much faster—it's a real performer."

"And of course," adds Marta, "Bob came back from his flight with a lot of things that I hadn't commented on, and we shared with each other."

Marta Bohn-Meyer worries that people outside the Dryden community may perceive them as workaholic airplane-heads. It's not true, she insists; they do their own gardening and landscaping at their home outside Lancaster, California. They run, ski, and hike. They have a dog.

Still, it's hard not to get the feeling the Meyers' hearts are really in the clouds as Marta wraps up her description of their other interests.

"Those things are real activities in our lives as well. Maybe not as much as flying. Well, definitely not as much as flying ..." •

Les Dorr wrote on airplane lightning research in our last issue. He works in the Office of Aeronautics and Space Technology for the Office of Public Affairs.

Titan

The Moon That Would Be A World

by Lynn D. Harper, ARC

After Voyager 1 transmitted the first close up pictures of Saturn and its moons in November 1980, bumper stickers on researchers' cars triumphantly proclaimed what the fly-by had confirmed: "Titan has Atmosphere!" What Voyager found was a strange but surprisingly familiar world, with an atmosphere more like Earth's than any other body in the Solar System.

Excitement mounted as the data poured in. Like Earth, Titan had an atmosphere composed primarily of nitrogen gas, only 50 percent denser than our own. The moon was blanketed with a smog-like haze, where a strangely mature organic chemistry was creating molecules important for the origin of life. Even more intriguing was the speculation that Titan might have a methane ocean, which would make it the only place other than Earth where a surface ocean exists.

Eleven years later, Saturn's largest satellite is still turning up surprises. The latest discovery—by researchers Chris McKay and James Pollack of the Ames Research Center and Regis Courtin of the Laboratory for Space Research at the Paris-Meudon Observatory—is the presence of an "anti-greenhouse" cooling effect on Titan. In fact, the moon experiences both greenhouse and anti-greenhouse effects.

A greenhouse effect occurs when a planet's—or in this case a moon's—atmosphere allows sunlight to reach the surface, but blocks the escape of heat back to space. The result: global warming. On Earth, carbon dioxide and water vapor trap infrared radiation (heat) near the ground. As a result, Earth's surface is about 80 degrees Fahrenheit warmer than it would be if the greenhouse gases were absent.

On Venus, where the carbon dioxide atmosphere is 90 times denser than Earth's, a runaway greenhouse effect drives temperatures 930 degrees Fahrenheit hotter than they would be without atmospheric warming. Mars has just the opposite problem. The thin Martian atmosphere, which also is mostly carbon dioxide, has only a negligible greenhouse effect because the atmospheric density is so low.

Out in the colder reaches of the Solar System, Saturn's smog-enshrouded satellite is providing new insights into the mysteries of global change.

Titan is smaller than Mars, but its atmosphere is 100 times denser. Hence it has a greenhouse effect—caused not by carbon dioxide and water as in the case of Earth, but by atmospheric nitrogen, methane, and hydrogen. Those gases should make Titan more than 40 degrees Fahrenheit warmer than it would be without an atmosphere. The fact that the surface is only 20 degrees Fahrenheit warmer led McKay, Pollack, and Courtin to the discovery of Titan's anti-greenhouse effect.

As the name implies, the anti-greenhouse effect is the exact opposite of what happens on Earth: Titan's atmosphere prevents sunlight from reaching the moon's surface, but allows heat to escape from the

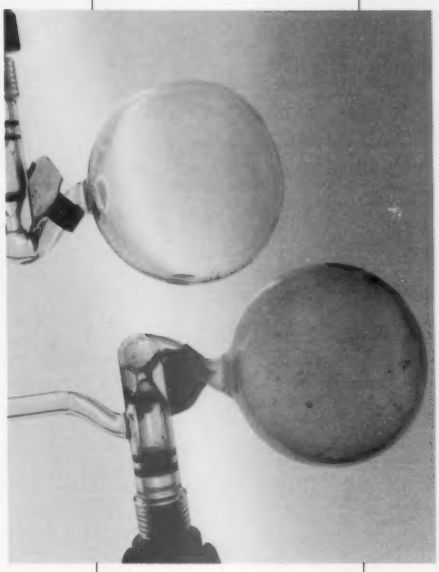
surface back to space. This anti-greenhouse effect results from the thick, permanent haze of organic molecules that extends down toward Titan's surface from an altitude of more than 300 miles. The haze absorbs so much radiation that only about 10 percent of the sunlight arriving at Titan can reach the surface. Even though it blocks incoming sunlight, the haze is virtually transparent to infrared energy, which radiates back to space. As a result, Titan becomes cooler. Without this high-altitude haze, the anti-greenhouse effect would be greatly reduced, the "normal" greenhouse effect would become even stronger, and the temperature on Titan would rise by about 70 degrees Fahrenheit.

The anti-greenhouse effect is amplified by the presence of methane gas which also absorbs sunlight, causing Titan's upper atmosphere to become warmer. Without any high-altitude anti-greenhouse effect, the "normal" greenhouse effect would become even stronger, and the temperature on Titan would rise by about 40 degrees Fahrenheit.

Besides being important to planetary scientists, the implications of this discovery for understanding the evolution of life on Earth are both sobering and profound. Some theories suggest that an anti-greenhouse effect occurred on Earth 65 million years ago, causing the extinction of approximately 90 percent of the species then living on the planet, and (incidentally) promoting the evolution of intelligent life.

If this theory is correct, the anti-greenhouse effect was caused by a giant planet-buster of a meteor that struck the Earth. The monstrous impact spewed megatons of debris into the air, blocking the sun for many weeks with a dust cloud that gradually and inexorably surrounded the planet. The abrupt and extreme cooling that followed caused an ice age that wiped out the dinosaurs and most other life on Earth.

When we next visit Titan, we'll most likely end up re-writing the textbooks—on planets, on moons, and maybe even on life in the universe.



Laboratory experiment replicates the effects of Titan atmospheric dynamics.

The threat of a catastrophic anti-greenhouse effect on Earth may not be over. Scientists fear that the kilotons of smoke and ash from the firestorms of a major thermonuclear war could create a manmade anti-greenhouse effect—the dreaded "Nuclear Winter"— that could rival the destructive power of a giant meteoritic impact.

However, until its recent discovery on Titan, no one knew whether an anti-greenhouse effect could exist on a scale large enough to dominate a planetary environment. Now scientists can study the causes and consequences of "global cooling" on a world that's larger than two of the nine planets we know—Mercury and Pluto. By studying the differences and similarities among planetary bodies, we gain important insights that would be impossible by studying one planet alone.

Further study of Titan is certain to uncover more surprises. One of the most enigmatic questions is why Titan should have a denser atmosphere than Earth, Mars, or any other moon in the Solar System. In fact, given its size, why does it have an atmosphere at all? Does an ocean exist under that thick blanket of smog? If it does, how would the interplay of atmosphere, ocean and land affect the complex organic chemistry occurring on Titan? And what clues does that chemistry hold for understanding the evolution of life here on Earth or elsewhere in the cosmos?

These are among the questions that will be addressed by the upcoming NASA-European Space Agency Cassini Orbiter and Huygens Probe mission. When we next visit Titan, we'll most likely end up re-writing the textbooks—on planets, on moons, and maybe even on life in the universe. •

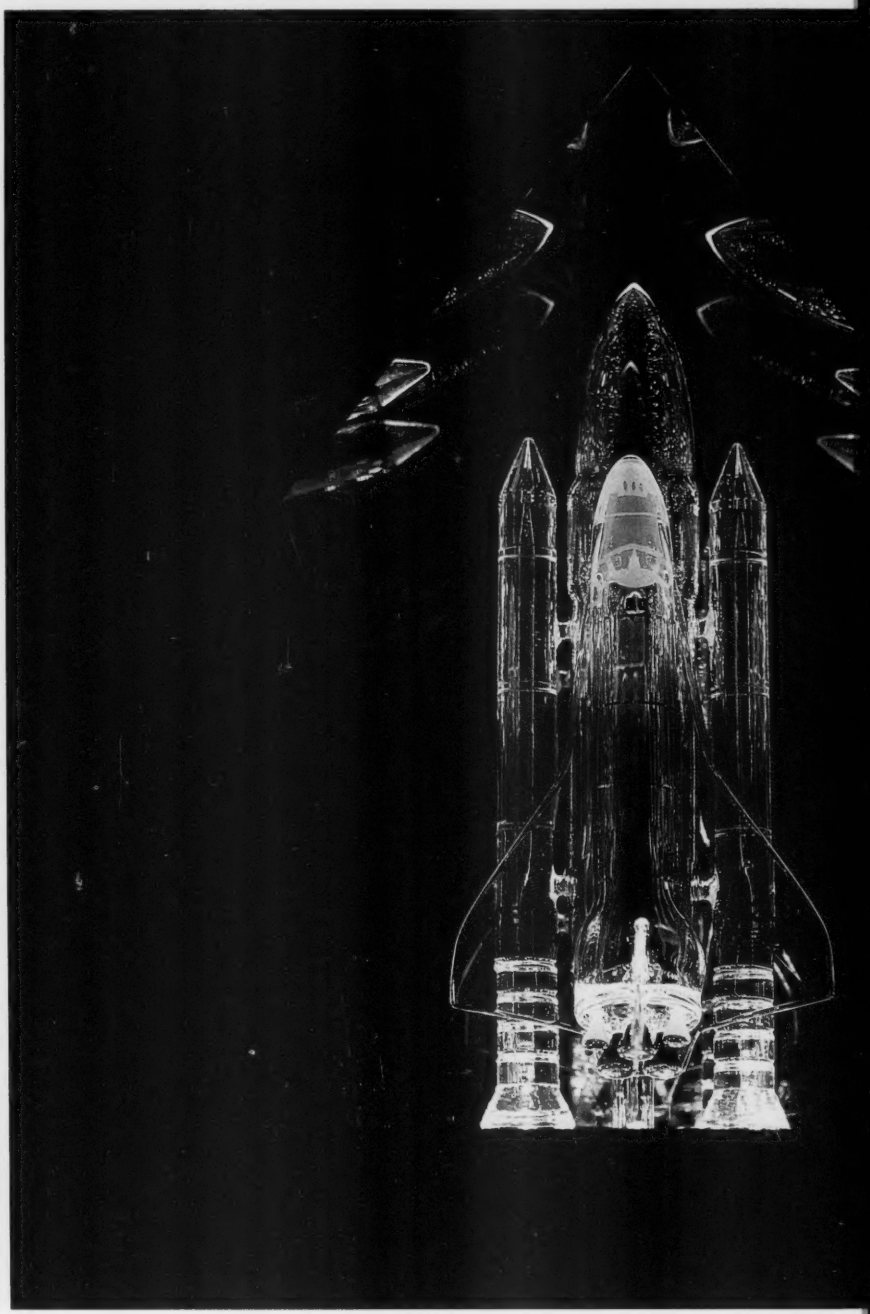
Lynn D. Harper is a former Program Manager of NASA's Exobiology Flight Program at Headquarters. Currently she is Deputy Chief for the Advanced Life Support Division at Ames.

In his own private corner of the Goddard Space Flight Center, Bob Harris has been creating scientific art and artful science for the past 22 years. As Goddard's only officially designated scientific glassblower-cum-artisan, Harris fashions glassware for delicate laboratory instruments that could someday fly aboard satellites. When he's not doing that, he's creating one-of-a-kind glass sculptures of many of those same spacecraft.

Harris admits that it's the models he enjoys making the most. "I'm an artist at heart," he says.

As you might expect, building glass components that could survive a jolting launch into space is challenging work. Even the pre launch tests are rough. Before satellites make it to the launch pad they're bombarded with sound waves, stressed to more than 20 times the force of gravity in a centrifuge and shaken violently on a vibration platform. Imagine the finest set of crystal goblets attached to a paint mixing machine, and you have a fair idea of what Bob Harris's creations have to survive. Glass instruments that took weeks to build often shatter into tiny pieces from this bull-in-a-china-shop treatment. When that happens, it's Bob Harris who heads back to the laboratory to start all over again.

Early in his NASA career, when a future of grinding lenses in Goddard's optics shop looked dim, Harris approached the center's



Spacecraft With

a Touch of Glass

Bob Harris combines precision, patience, and determination to create unique works of art.

by Beth Schmid, Hq.

original glassblower, George Bergen. Harris had been interested in Bergen's work for some time, and began coaxing the glassblower to teach him his art. Bergen finally agreed, and Harris became his apprentice for the next four years. He proved to be an able student, and when Bergen was promoted in 1972, Harris succeeded him as Goddard's only glassblower.

One of the first and foremost lessons he learned was the need for precision, patience and determination. He couldn't simply rely on a machine to make the right size of glass. According to Harris, measuring a glass piece with an instrument while it's being made is very difficult. So he uses his eyes as the primary measuring device and his hands as the principal tool.

The physical properties of glass—its non-conductivity and imperviousness to chemicals, for example—make it ideal for certain space applications. Harris has built glass springs, glass parts for atomic clocks, glass lasers, special lamps with lenses for optical windows and glassware to fly on NASA balloons. He even holds a patent on a method for fabricating a Mass Spectrometer Inlet Leak used to measure chemically reactive species around Venus. Typically, a scientist who comes to Harris with a glass-making project gives him a "little sketch of a design." Harris might then take the crude pencil drawing, discuss with the scientist exactly what's needed, make

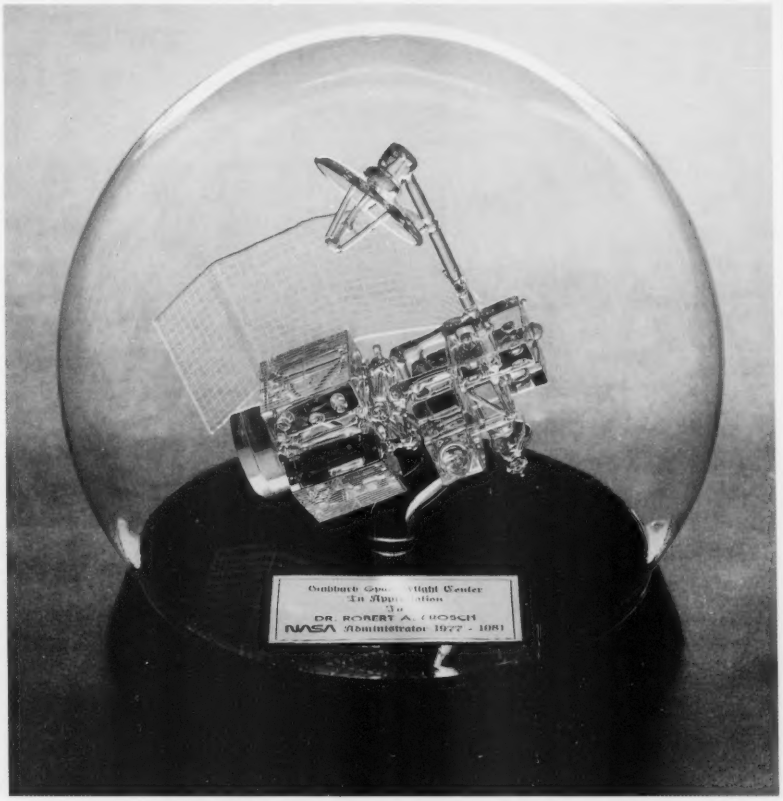
suggestions for improvements, and then go into fabrication.

One of Harris's projects required that he seal a piece of wire, thinner than a strand of human hair, into the tip of a piece of glass smaller than a toothpick. "I can do things with glass that were thought to be impossible!" he boasts.

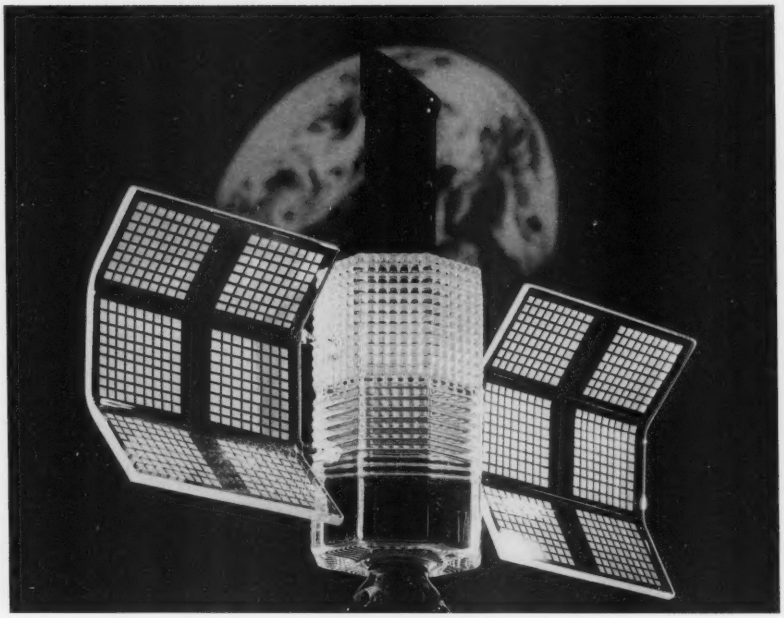
Depending on the project, Harris says, "There have been times when my lab looked like what you see in old Frankenstein movies," with beakers bubbling, burners flaring, light lasing and glass shattering. But in fact, researching a project and developing a procedure to make it work are what take most of his time. "I only spend about 10 percent of my time on the actual glassblowing—the rest is spent figuring out how to work the glass in a new way. Every project is fascinating," he says.

One of Harris's projects required that he seal a piece of wire, thinner than a strand of human hair, into the tip of a piece of glass smaller than a toothpick. "I can do things with glass that were thought to be impossible!" he boasts.

With all that creativity going on, Harris's lab is an exciting place for students of all ages, and he has conducted numerous student workshops both at Goddard and at schools and universities. Invariably, the students are in awe of both the glassblown objects and their creator. One group of teenagers who toured Harris's lab presented him with a wall plaque filled with fond messages. He points to one: "Don't ever change your wild personality, Bob. It would really REEK, man." Harris turns a shade sentimental. "They really do make it all worthwhile."



Bob Harris's spacecraft models display the artistry and precision of the spacecraft elements he makes.



A down-to-Earth version of one of NASA's priceless, orbiting objects.

Harris attributes his ability to craft glass to his hobby of building models as a kid. "I was into model making at an early age," he says. "Of course, glass is far more difficult to work with, but it's that challenge that made me want to learn the art of glassblowing."

When the need for scientific glassware eventually declined due to advances in easily machinable alloys, Goddard began to draw more heavily on Harris's artistic abilities. Early in his career he had been called upon occasionally to craft special glassblown spacecraft to be presented to VIP's visiting the center. As his artistic work became better known around Goddard, Harris's services became more and more in demand.

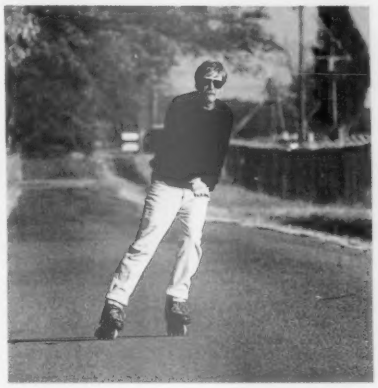
He says that his two sides complement each other. "There's no way I'd be able to make models of spacecraft without my scientific background. And I find experimenting artistically reveals ideas I can use in my scientific work."

A few years ago, he made a glassblown scene of the Solar Maximum Repair Mission for presentation to President Reagan. The whole time he was working on the project, hardly anyone got to see or hear about its progress. "It's just not necessary for anyone else to see what I do. I have yet to fail in any request," he says. He spent evenings, weekends and all his spare time in a tireless effort to finish the spacecraft for the President's visit, and—of course—completed it punctually and perfectly.

But what else would you expect from a guy with enough energy to roller blade every day at lunchtime?

Sure enough, the 52-year-old Harris can be found wheeling around the center most every lunch hour. Asked if he's afraid that he might break his neck, he responds, "Not me. Anyway, this is nothing compared to riding my Harley! I can tell you anything you want to know about Harley-Davidson, from the inception of the company until now! Or do you like Corvettes? I know all about those, too. I've got one at home."

Harris's artistic creations demand a scientific background.



Roller-blading across the Goddard Space Flight Center provides lunchtime exercise and relaxation.

It's not all glass. Harris is an expert model helicopter enthusiast.

Besides the Solar Max piece for President Reagan, Harris has made exquisite glass models of other NASA spacecraft, including Galileo, the Tracking and Data Relay Satellite, and his *piece de resistance*, a splendid, glowing, glass-encased Space Shuttle. His biggest lament in recent years is that he saw his completed creations for only a few hours before he had to give them away.

Harris's masterpieces now reside all around the country, with a few in Europe, too. Fortunately, Harris made an extra model of the shuttle, which he says he wouldn't part with for anything.

For Bob Harris, being the best is not limited to his "on the job" life. He was in Australia recently to help judge what he calls the "Olympics of model aircraft contests." A model helicopter enthusiast and expert himself, Harris was one of five judges chosen to preside over this international competition representing modelers from 17 countries. He has competed in the past with his own helicopter models, and still does.

And, as with every new venture he undertakes, Bob Harris does it with a touch of class. ●

Beth Schmid is Associate Editor of *NASA MAGAZINE* and is Assignment Editor for NASA Select Television in the Office of Public Affairs.

LANGLEY

Model Performance

High above the uninhabited dry salt marsh of Langley's Plum Tree Test Site, a model of the X-31 experimental aircraft is being flown to study the more risky aspects of the plane's flight characteristics.

Langley engineering technician Robert F. Bryant, Jr., awaits the countdown before releasing the 12-foot X-31 drop model.

How it stalls, spins, and acts after stalling are some of the performance capabilities being examined by researchers.

The X-31 experimental aircraft is designed to examine high angle of attack (a nose-high attitude relative to the flight path) flying tactics. The model flights closely replicate that of the full-scale aircraft.

Unlike wind tunnel models, drop models allow investigation of large magnitude, dynamic flight maneuvers. Carried aloft by helicopter, they are released and piloted by remote control and tracked visually from the ground while data is gathered and the flight is recorded on video. A parachute recovery assures a soft landing. ●

MARSHALL

Smaller Candles Shed Great Light

When a Space Shuttle thunders its way into orbit, there is no ignoring the tremendous 5.8 million pounds of thrust developed by its twin solid rocket engines—the equivalent of 44 million horsepower. It's an attention grabber.

Marshall researchers are paying attention to more diminutive solid rocket models to make sure U.S. solid rocket technology remains tops. In early November, the solid propulsion team successfully fired a 20-foot long, 48-inch-diameter, subscale solid rocket motor for a full duration of 28 seconds.

Marshall engineers are using the tests to learn more about solid rocket motor insulation and nozzle materials. Specialized instrumentation is used to monitor the performance of the motor elements and computer analysis of the subscale tests provide a much better idea of how new elements will act in full-scale tests. ●

KENNEDY

A Leg Up for Science

Astronauts returning from Space Shuttle missions are, of course, the best subjects for studying microgravity's harmful effects on the human body. But Earth-bound NASA researchers have teamed up with the Holmes Regional Medical Center in Melbourne, Florida, to replicate those effects using Kennedy Space Center volunteers as test subjects. These surrogate astronauts walk on crutches with one leg suspended for up to six weeks at a time. Using the medical center's Magnetic Resonance Imaging device, scientists are able to see extremely detailed images of muscles, organs and other tissues. Preliminary results from these studies— which benefit both the medical community and future space travelers—show that the test subjects lose between 12 and 20 percent of their muscle mass during a six-week period. Another test is slated to begin early this year. ●

LEWIS

In the Year 2041

Capping a ten-month long celebration of a half-century of contributions to aeronautics and space, Lewis Research Center sent a message to the future. In late October, the center sealed a time capsule/sculpture in ceremonies that saluted the future citizens of Lewis, Cleveland, and the nation.

The message recalled the work to quiet airplane engines, to help lift Space Shuttles off their launch pads, to help humans walk in space, to improve life conditions on Earth, to develop power sources, to improve world conditions, and enhance medical science with unique and effective research tools.

50th Anniversary art contest winner Sylvia Hathaway accepts congratulations from Lewis external programs director John Hairston.

Underlining the Lewis commitment to the future, the center celebrated the partnership made with Cleveland area schools with the planting of an Ohio buckeye tree. ●

JPL

Beyond the Edge

After fourteen years of spectacular discovery, the twin Voyager spacecraft are navigating their separate courses, now probing for the edge of the solar system.

Voyager 1, some 4.3 billion miles from Earth, and Voyager 2, 3.3 billion miles from Earth, are traveling in opposite directions in a new phase of their exploration careers called the Voyager Interstellar Mission.

Mission scientists now expect the Voyagers to cross the "termination shock" by the end of the century. The termination shock (where the solar wind starts slowing down) is the first sign that the probes are approaching the heliopause, the outermost boundary of the solar wind. Though the exact location of where the solar system ends remains a mystery, it has long been thought to be located 75 to 150 astronomical units (one astronomical unit equals 93 million miles) from the sun.

Outward bound, the Voyagers continue on duty. Both are involved in an extensive program of ultraviolet astronomy, studying active galaxies, quasars and white dwarf stars. And while some capabilities of the spacecraft will dwindle, barring any catastrophies, Voyagers may continue to report on the vast reaches of space for twenty or even 30 more years. ●

AMES

Cutting Edge Ribbon Cutting

Research to help scientists design computers to simulate human intelligence will be aided by a new Biocomputation Center opened this summer at Ames.

The Ames Life Science Division is leading a research team studying the three-dimensional makeup of biological neural networks (a series of connections between the nerves). The team hopes to discover the basic principles of how nerves are organized and function.

The scientists have used high-performance computers and graphics workstations to produce the first reconstructions of a neural network based on a living system. Information gained from the study of biological

Ames life science officials open Biocomputation Center.

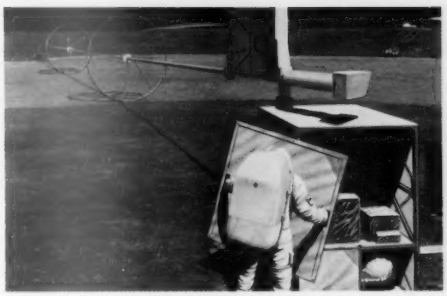
systems may be useful in developing future computers, particularly parallel processors. By using computers to construct three dimensional models of biological neural networks and reducing these detailed models to a mathematical level, it may be possible to design and build electronic circuits to mimic the biological circuits. These types of circuits could prove valuable used in concert with systems in mobile robots. ●

JOHNSON

Living Off the Fat of the Moon

Scientists and engineers in JSC's Solar System Exploration Division and the Lunar and Mars Exploration Program Office are working on the support systems that would be needed for a manned lunar base. And some of the basic essentials needed for living on the moon just might be available right there.

At a seminar held at JSC in October, water condensed from materials found on the moon flowed through a special demonstration unit. Though water itself is not present on the moon, its components are contained in the lunar soil. If efficient methods can be developed to make water from materials on the moon, it could mean significant savings in long-term operating costs of a lunar base. Factors considered in evaluating processes include simplicity, amount of resupply materials needed, energy requirements, size of the processing plant and the raw materials readily available.



One process produces water from ilmenite, a compound composed of iron, titanium and oxygen, and found abundantly in lunar soil. Eight candidate processes evaluated for recovering water on the lunar surface were presented at the first In-Situ Resource Utilization seminar. ●

Prior to stepping down as deputy administrator last November, J. R. Thompson reflected on his career at NASA and the agency's last quarter-century, and looked to the future. "Despite what the critics may say," Thompson noted, "for NASA, the times have never been better."

The Best of Times Bar None

by James R. Thompson

The Agency has changed a lot in the last quarter of a century. I've seen it through the so-called heyday of Apollo, through its lean budget years, and on into the Shuttle era. Frankly, despite what the critics may say, for NASA the times have never been better.

First, the Agency is strong and its foundations are solid, with a good variety of programs underway. In the early days I could count on one hand the number of programs NASA had going. Today, we've literally got hundreds—from aeronautics to technology, from space transportation to science.

Second, our political support is strong. Both the Administration and Congress are behind NASA, and that support is bipartisan. Third, the American people believe in what we do. Tens of thousands go down to Florida to watch the shuttle launch, and they do it because they know it's American know-how at risk. They even show crew wake-up calls on national news, because the American people take pride in the program. Finally, NASA's people are solid. They are simply in a class by themselves.

Is the Agency trying to do too much today? I don't believe it is. We recently did an assessment, asking ourselves, "Where would we want to stop? Where would we want to cut?" We kept running into the same problem. Aeronautics means too much to the country. Technology is our investment in the future. Science is what it's all about. And exploration is very clearly the major goal of NASA. They're *all* valuable.

Are we trying to do too much with the budget we've got? That's a more legitimate question. I personally don't think we're investing enough in space. But the budget is proposed by the President and appropriated by Congress, and NASA has to get its programs in line with those decisions. With that in mind, I'd look ahead to the next two years as a time to consolidate, to absorb the post-Challenger growth. I expect that after the middle of this decade, there's going to be more opportunity for future expansion.

The Agency now has the chance to re-think how we use the space shuttle. The shuttle could stay in space a lot longer than it does today, with flights lasting up to three months. I think we could achieve that capability in a very cheap way.

"For those just coming into NASA today, all I can say is that the agency's opportunities are outstanding...I just wish I could do it all over again."

The restructured space station—which we need if we're ever to go to Mars or stay on the Moon for extended periods of time— could be used earlier than we're now planning, first by docking the shuttle to it for extended missions of up to six months. Later on we can dock labs and habitats permanently, and let the station grow gracefully. And if we marry the station with the shuttle, we won't have to wait until Freedom is permanently occupied to start using it.

As for free advice: I think sometimes NASA could use a little more internal controversy. You're not working with easy issues, and I think it's proper to stimulate the best ideas in a constructive way. Second, you just can't be afraid to fail. That's not to say you shouldn't measure or consider risk in what you do. But I've collected a lot of burn marks on me over the past 25 years.

For those just coming into NASA today, all I can say is that the agency's opportunities are outstanding. I just wish I was your age and could do it all over again. ●

James R. Thompson retired as deputy administrator of NASA on November 8, 1991. He was called from Princeton's Plasma Physics Laboratory to serve as director of Marshall Space Flight Center during NASA's "return to flight" efforts following the Challenger disaster. He first joined NASA at Marshall in 1963.

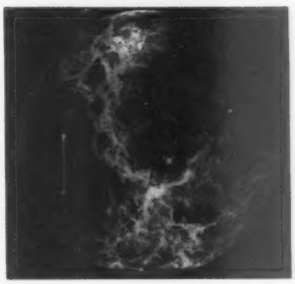
UPCOMING LAUNCHES

● Launch of STS-42 Discovery on a seven day international spacelab science and technology mission. Crew for the mission include Stephen S. Oswald, Norman E. Thagard, David Hilmer, William F. Readdy, Roberta L. Bondar, Ulf D. Merbold

UPCOMING FLYBYS

15
JANUARY

Magellan begins third mapping cycle of Venus.



8
FEBRUARY

Ulysses gets a gravitational-assist in a flyby maneuver of Jupiter. The trip to the sun to investigate its polar characteristics takes a turn around the giant planet.

UPCOMING EVENTS

1
JANUARY

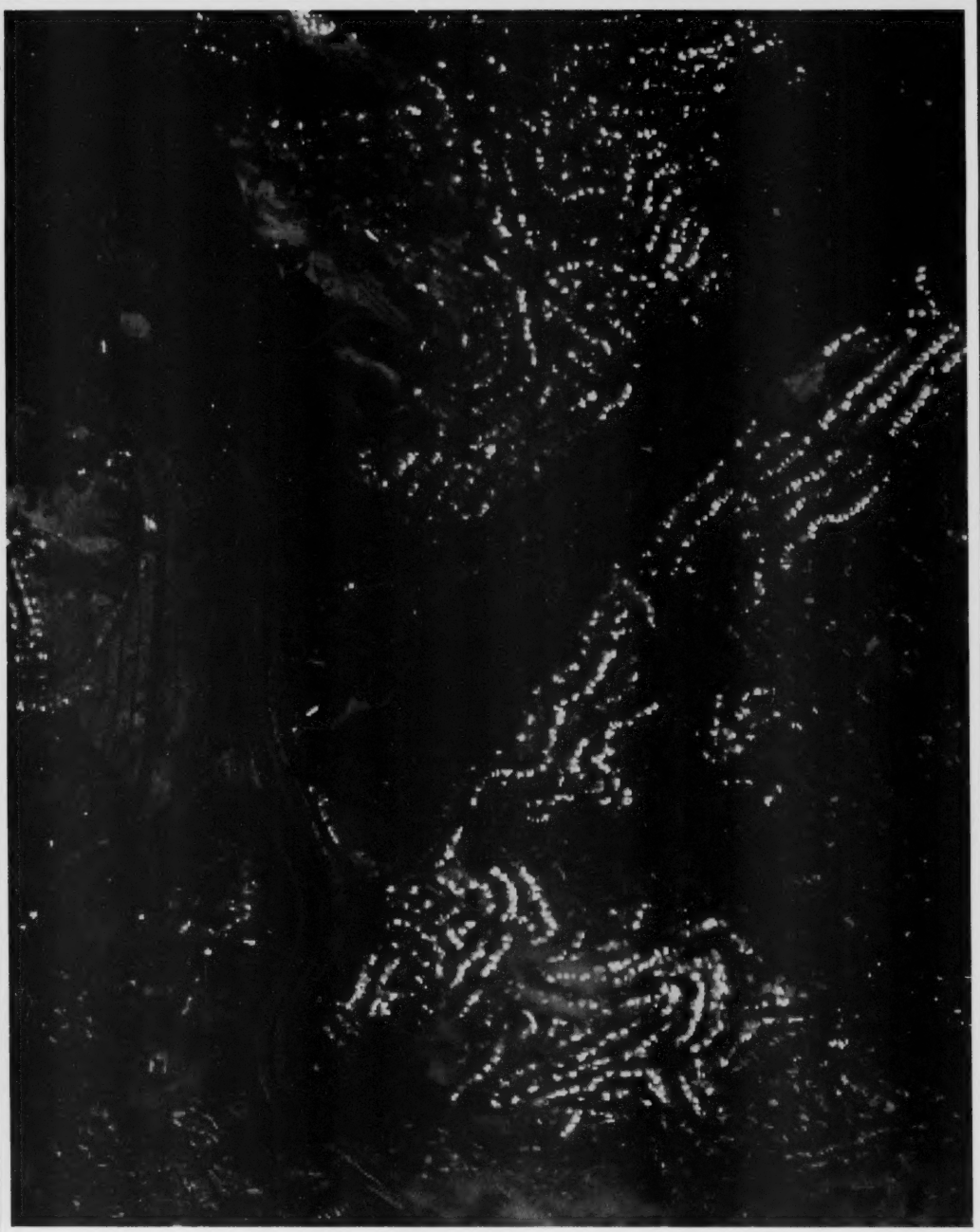
Beginning of the International Space Year.

24
JANUARY

Sixth Anniversary of Voyager Uranus Flyby.

IN OUR NEXT ISSUE

The NASA Art Collection and U.S. space artists visit the Soviet space program.



The recent Oakland Berkeley Hills conflagration is shown in this remote sensing data. Imaged from 6,000 ft. by the Thematic Mapper Simulator aboard a NASA C-130 aircraft, the data reveals burning structures through a pall of smoke. Firefighters could use such technology to marshal their resources.